# DOCUMENT RESUME

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TITLE Military Curriculum Materials for Vocational and Technical Education. Masonry Specialist I & II, 3-19.

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SPONS AGENCY Office of Vocational and Adult Education (ED), Washington, DC.

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IDENTIFIERS *Cement; Military Curriculum Project

ABSTRACT

These military-developed curriculum materials consist of a course description, plan of instruction, study guides, and workbooks for use in training masonry specialists. Covered in the course blocks are an introduction to masonry and rigid concrete structures. The introduction to masonry, course block I, deals with safety, mathematics and estimating, project planning, maintenance of tools and equipment, and construction layout. Addressed in course block II, on rigid concrete structures, are the following topics: concrete mixtures, preparing for concrete, reinforcement materials and tools, mixing and placing concrete, curing concrete, and concrete maintenance and repair. (MN)

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# Military Curriculum Materials for Vocational and Technical Education

Masonry Specialist I & II
3-19

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION

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FOR RESEARCH IN VOCATIONAL EDUCATION
THE OHIO STATE UNIVERSITY
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CE 033343

# MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

# The National Center Mission Statement

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- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

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Military Curriculum Materials
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# Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education

# Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

**Project Staff:**

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

# What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

# How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

## CURRICULUM COORDINATION CENTERS

**EAST CENTRAL**
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

**MIDWEST**
Robert Patton
Director
1515 West Sixth Ave.
Stillwater, OK 74074
405/377-2000

**NORTHEAST**
Joseph F. Kelly, Ph.D.
Director
225 West State Street
Trenton, NJ 08625
609/292-6562

**NORTHWEST**
William Daniels
Director
Building 17
Airdustrial Park
Olympia, WA 98504
206/753-0879

**SOUTHEAST**
James F. Shill, Ph.D.
Director
Mississippi State University
Drawer DX
Mississippi State, MS 39762
601/325-2510

**WESTERN**
Lawrence F. H. Zane, Ph.D.
Director
1776 University Ave.
Honolulu, HI 96822
808/948-7834

# MASONRY SPECIALIST, I AND II

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Block I - Introduction to Masonry

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# MASONRY SPECIALIST, I AND II

Classroom Course

Developed by

United States Air Force

Development and Review Dates

August 15, 1974

D.O.T. No.:
859.884

Occupational Area:
Building and Construction

Target Audiences:
Grades 10-adult

Print Pages:
525

Cost:
$10.75

Availability:
Military Curriculum Project, The Center for Vocational Education, 1960 Kenny Rd., Columbus, OH 43210

| Contents | Type of Materials: | | | | | | Instructional Design: | | | | Type of Instruction: | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lesson Plans: | Programmed Text: | Student Workbook: | Handouts: | Text Materials: | Audio-Visuals: | Performance Objectives: | Tests: | Review Exercises: | Additional Materials Required: | Group Instruction: | Individualized: | |
| | | | No. of pages | | | | | | | | | | |
| Block I—*Introduction to Masonry* | | | 87 | | | | | * | | | | | |
| Safety | • | | • | | • | | • | | | * | • | | |
| Mathematics and Estimating | • | • | • | | • | | • | | | * | • | | |
| Project Planning | • | | • | | • | | • | | | * | • | | |
| Maintenance of Tools and Equipment | • | | • | | • | | • | | | * | • | | |
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| Concrete Mixtures | • | | • | | • | | • | | | * | • | | |
| Preparing for Concrete | • | | • | | • | | • | | | * | • | | |
| Reinforcement Materials and Tools | • | | • | | • | | • | | | * | • | | |
| Mixing and Placing Concrete | • | | • | | • | | • | | | * | • | | |
| Curing Concrete | • | | • | | • | | • | | | * | • | | |
| Concrete Maintenance and Repair | • | | • | | • | | • | | | * | • | | |

* Materials are recommended but not provided.

Expires July 1, 1978

## Course Description

This course is part of a two course series designed to provide instruction in the following areas: an introduction to masonry, hand, portable power, and shop tools; construction and maintenance of masonry structures using clay, brick, concrete block, stone, and tile; preparation of concrete, mortar, and plaster mixes; placement of reinforcing steel; and the placement and finishing of concrete. This course, **Masonry Specialist, I and II**, consists of two blocks totaling 94 hours of instruction. **Masonry Specialist, III and IV** (course 3-20 in this catalog), contains two blocks, Block III—*Laying Concrete Block, Stone, and Brick*, and Block IV—*Plaster, Stucco, and Tile*, totaling 118 hours of instruction.

Block I—*Introduction to Masonry* contains five lessons totaling 36 hours of instruction. Four sections dealing with military organization and procedures were deleted. The remaining sections are suitable for vocational programs.

- Safety (2 hours)
- Mathematics and Estimating (6 hours)
- Project Planning (6 hours)
- Maintenance of Tools and Equipment (12 hours)
- Construction Layout (10 hours)

Block II—*Rigid Concrete Structures* contains six lessons totaling 58 hours of instruction.

- Concrete Mixtures (6 hours)
- Preparing for Concrete (12 hours)
- Reinforcement Materials and Tools (6 hours)
- Mixing and Placing Concrete (12 hours)
- Curing Concrete (6 hours)
- Concrete Maintenance and Repairs (16 hours)

The course contains materials for both student and teacher use. Printed materials for the instructor include a plan of instruction for each block and lesson plans for each lesson. These plans include an outline of instruction, objectives, activities, materials and tools needed, text assignments, and references. Student materials consist of study guides and workbooks for each block plus two programmed texts for Block I. Transparency sets are recommended for each lesson, but are not provided.

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# PLAN OF INSTRUCTION

(Technical Training)

## MASONRY SPECIALIST

AIR TRAINING COMMAND

SHEPPARD TECHNICAL TRAINING CENTER

12 November 1975-Effective 13 January 1976 with class 760113

POI 3ABR55233

## LIST OF CURRENT PAGES

This POI consists of 69 current pages issued as follows:

| Page No. | Issue |
|---|---|
| Title | Original |
| A | Original |
| i | Original |
| 1 thru 5 | Original |
| 6 | Blank |
| 7 thru 11 | Original |
| 12 | Blank |
| 13 thru 19 | Original |
| 20 | Blank |
| 21 thru 23 | Original |
| 24 | Blank |
| 25 thru 39 | Original |
| 40 | Blank |
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| 55 thru 59 | Original |
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| 61 thru 63 | Original |
| 64 | Blank |
| 65 and 66 | Original |

DISTRIBUTION: ATC/TTMS-1, AUL/LSE-1, CCAF/AY-2, MOM-1, TCE-75, TTOX-2, TTOT-1, TTOR-1, TTE-1.

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3ABR55233 **COURSE CHART – TABLE II – TRAINING CONTENT**

NOTE: Include time spent on technical training (TT) (classroom/laboratory (C/L) and complementary technical training (CTT)) and related training (RT). Exclude time spent on individual assistance (remedial instruction). A single entry of time shown for a unit is C/L time. When a double entry is shown, the second entry is CTT time.

| WK OF TNG / HRS PER DAY | 1 2 3 4 5 6 | 7 8 |
|---|---|---|
| 1<br>2(4/5) | Course Material - UNCLASSIFIED 58 Hours TT<br>BLOCK I - Introduction to Masonry<br>Orientation (2 hrs); Base Civil Engineer Organization (4 hrs); Safety (2 hrs); Project and Resource Management (4 hrs); Mathematics and Estimating (6 hrs); Project Planning (6 hrs); Publications (6 hrs); Maintenance of Tools and Equipment (12 hrs); Construction Layout (10 hrs); Measurement Test and Test Critique (2 hrs).<br>(Equipment Hazards and Personnel Safety Integrated with Above Subjects)<br>54 Hours C/L | 14 Hours RT<br>4 Hours CTT |
| 2(1/5)<br>3<br>4(4/5) | Course Material - UNCLASSIFIED 80 Hours TT<br>BLOCK II - Rigid Concrete Structures<br>Concrete Mixtures (6 hrs); Preparing for Concrete (12 hrs); Reinforcement Materials and Tools (6 hrs); Mixing and Placing Concrete (12 hrs); Curing Concrete (6 hrs); Concrete Maintenance and Repairs (16 hrs); Measurement Test and Test Critique (2 hrs).<br>(Equipment Hazards and Personnel Safety Integrated with Above Subjects)<br>60 Hours C/L | 20 Hours CTT |

DEPARTMENT OF THE AIR FORCE
USAF Sch of Applied Aerosp Sci (ATC)
Sheppard Air Force Base, Texas 76311

PLAN OF INSTRUCTION 3ABR55233
(PDS Code NDO)
12 November 1975

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## FOREWORD

1. PURPOSE: This publication is the plan of instruction (POI) when the pages shown on page A are bound into a single document. The POI prescribes the qualitative requirements for Course Number 3ABR55233, Masonry Specialist, in terms of criterion objectives and teaching steps presented by units of instruction and shows duration, correlation with the training standard, and support materials and guidance. When separated into units of instruction, it becomes Part I of the lesson plan. This POI was developed under the provisions of ATCR 50-5, Instructional System Development, and ATCR 52-7, Plans of Instruction and Lesson Plans.

2. COURSE DESIGN/DESCRIPTION. The instructional design for this course is Group/Lock Step. The course trains airmen to perform duties prescribed in AFM 39-1 for Apprentice Mason AFSC 55233. Training includes an introduction to masonry and provides instruction on mason's hand, portable power, and shop tools; construction and maintenance of masonry structures using clay brick, concrete block, stone, and tile; preparing concrete, mortar and plaster mixes; placing reinforcing steel; and placing and finishing concrete. In addition, related training is provided on driver education, troop information program, commander's calls/briefings, etc.

3. TRAINING EQUIPMENT. The number shown in parentheses after equipment listed as Training Equipment under SUPPORT MATERIALS AND GUIDANCE is the planned number of students assigned to each equipment unit.

4. REFERENCES. This plan of instruction is based on Specialty Training Standard 552X3, 15 March 1973; Change 1, 17 July 1973; Change 2, 5 September 1974; Change 3, 31 July 1975, and Course Chart 3ABR55233, 4 November 1975.

FOR THE COMMANDER

LEONARD A. HAMILTON, Colonel, USAF
Chief, Dept of Civil Engineering Tng

Supersedes Plan of Instruction 3ABR55233, 1 April 1974; Change 15 August 1974.
OPR: Department of Civil Engineering Training
DISTRIBUTION: Listed on page A

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# MODIFICATIONS

Pages 1-5 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

# PLAN OF INSTRUCTION/LESSON PLAN PART I

| NAME OF INSTRUCTOR | COURSE TITLE |
|---|---|
|  | Masonry Specialist |

| BLOCK NUMBER | BLOCK TITLE |
|---|---|
| I | Introduction to Masonry |

| 1 COURSE CONTENT | 2 DURATION (Hours) |
|---|---|
| 3. Safety | 2<br>(2/0)<br>Day 2 |
| a. Given a picture containing safety hazards that may be encountered when using or maintaining masonry tools and equipment, identify these hazards and explain how to eliminate them. All hazards must be identified. STS 6a(1), 6a(2), 6a(3), 6b Meas: W, PC<br>(1) Causes of accidents<br>(2) Work area hazards<br>(3) Electrical hazards<br>(4) Housekeeping requirements<br>(5) First aid | (0.5/0) |
| b. Using given procedures, erect a ladder and scaffold so that it complies with all safety regulations. STS 6a(4). Meas. W, PC<br>(1) Scaffolds<br>(2) Ladders | (1/0) |
| c. Exercise safety precautions while lifting a heavy object from the floor to a full upright position. The correct body position must be used and all safety precautions observed. STS 6a(5). Meas: W, PC<br>(1) Possible effects of not lifting correctly<br>(2) Correct lifting procedures | (0.5/0) |

SUPERVISOR APPROVAL OF LESSON PLAN (PART II)

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| 3ABR55233 | 12 November 1975 | 7 |

ATC FORM APR 75 133 REPLACES ATC FORMS 337, MAR 73, AND 770, AUG 72, WHICH WILL BE USED.

# SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SG 3ABR55233-I-3, Safety
WB 3ABR55233-I-3-P1, Safety

Audio Visual Aids
Transparencies, Safety

Training Equipment
Pipe Scaffolding (12)
Ladder (12)
Hand Tools for Masonry (2)

Training Methods
Discussion (1 hr)
Performance ([illegible] hr)

Multiple Instructor Requriements
Supervision (2)

Instructional Guidance
Discuss and demonstrate the procedures for lifting heavy objects to prevent back injuries. Demonstrate the proper methods of erecting scaffolds and ladders. Discuss electrical hazards, first aid, and work area safety practices. The following reference should be used in preparing this lesson: AFR127-101, Ground Accident Prevention Handbook.

MIR: Two instructors will be required when the student erects the scaffolding.

# MODIFICATIONS

Pages 9 -11 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

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## PLAN OF INSTRUCTION/LESSON PLAN PART I

| NAME OF INSTRUCTOR | COURSE TITLE |
|---|---|
| | Masonry Specialist |

| BLOCK NUMBER | BLOCK TITLE |
|---|---|
| I | Introduction to Masonry |

| 1 COURSE CONTENT | 2 DURATION (Hours) |
|---|---|
| 5. Mathematics and Estimating | 6<br>(6/0)<br>Day 3 |
| a. Solve arithmetic problems consisting of whole numbers, fractions, and decimals. All given problems must be solved correctly. STS 7c and 7d. Meas: W, PC | (5/0) |
| (1) Addition | |
| (2) Subtraction | |
| (3) Multiplication | |
| (4) Division | |
| b. Given a simple sketch of a masonry project, estimate the types and amount of materials and the man-hours required. Estimates must be within -0% and +10% of those found by the instructor. STS 7c and 7d. Meas: W, PC | (1/0) |
| (1) Unit of measure of masonry building materials | |
| (2) Determining types and quantity of materials required | |
| (3) Estimating procedures | |
| (4) Equipment and tools | |

SUPERVISOR APPROVAL OF LESSON PLAN (PART II)

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ATC FORM APR 75 133 REPLACES ATC FORMS 337, MAR 73, AND 770, AUG 72, WHICH WILL BE USED.

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PLAN OF INSTRUCTION/LESSON PLAN PART I (Continuation Sheet)

COURSE CONTENT

## SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SG 3ABR55233-I-5, Mathematics and Estimating
WB 3ABR55233-I-5-P1, Arithmetic Problems and Estimating Procedures

Audio Visual Aids
Transparencies, Mathematics and Estimating

Training Methods
Discussion (2 hrs)
Demonstration (1 hr)
Performance (3 hrs)

Instructional Guidance
Review simple arithmetic problems and demonstrate how these procedures are used by the masonry specialist. Explain the methods used to estimate material and man-hours required for a given masonry project.

The following references should be used in preparing the lesson:
AFR 85-1, Resources and Work Force Management
2TPT-5111-01, Basic Math-Fractions
2TPT-5111-02, Basic Math-Decimals
CDC 55233, Apprentice Mason

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## PLAN OF INSTRUCTION/LESSON PLAN PART I

| | |
|---|---|
| NAME OF INSTRUCTOR | COURSE TITLE<br>Masonry Specialist |
| BLOCK NUMBER<br>I | BLOCK TITLE<br>Introduction to Masonry |

| 1 COURSE CONTENT | 2 DURATION (Hours) |
|---|---|
| 8. Project Planning | 6<br>(6/0)<br>Day 4 |
| a. Using the assigned engineering drawing, interpret a list of given items. Each item must be interpreted correctly. STS 7a and 7b. Meas: W, PC<br>(1) Type of work<br>(2) Work location<br>(3) Configuration of the job | (1/0) |
| b. Given the types of lines, symbols, and required scales, prepare a sketch of a masonry project. Finished sketch must be complete enough to use as a working drawing. STS 7a and 7b. Meas: W, PC<br>(1) Purpose of drawings<br>(2) Symbols<br>(3) Types of lines<br>(4) Making a sketch | (5/0) |

SUPERVISOR APPROVAL OF LESSON PLAN (PART II)

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ATC FORM APR 75 133 REPLACES ATC FORMS 337, MAR 73, AND 770, AUG 73, WHICH WILL BE USED.

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PLAN OF INSTRUCTION/LESSON PLAN PART I (Continuation Sheet)

COURSE CONTENT

## SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SG 3ABR55233-I-6, Project Planning
WB 3ABR55233-I-6-P1, Planning a Masonry Project
Engineering Drawings

Audio Visual Aids
Transparencies, Project Planning

Training Methods
Discussion (2 hrs)
Demonstration (1 hr)
Performance (3 hrs)

Instructional Guidance
Discuss sketch drawing, blueprint reading, symbols, and alphabet of lines. Demonstrate the method of using an engineering drawing to plan a work project. The following references should be used to prepare the lesson: AFR 85-1, Resources and Work Force Management, and CDC 55233, Apprentice Mason.

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## PLAN OF INSTRUCTION/LESSON PLAN PART I

| NAME OF INSTRUCTOR | COURSE TITLE |
|---|---|
| | Masonry Specialist |

| BLOCK NUMBER | BLOCK TITLE |
|---|---|
| I | Introduction to Masonry |

| 1 COURSE CONTENT | 2 DURATION (Hours) |
|---|---|
| 8. Maintenance of Tools and Equipment | 12<br>(12/0)<br>Days 6 and 7 |
| a. Working as a member of a six-man team and using a school technical order file, clean, sharpen, repair, and maintain masonry tools and equipment. All work must comply with TO 32-1-101. STS 8a, 8b, 8c, 8d, and 10j(3). Meas: W, PC | (6/0) |
| (1) Hand tools | |
| (2) Concrete mixer | |
| (3) Concrete saw | |
| (4) Air compressor | |
| (5) Paving breaker | |
| (6) Pneumatic tamper | |
| (7) Vibrator tamper | |
| (8) Power trowel | |
| (9) Mortar mixer | |
| (10) Tile saw | |
| (11) Electric drill | |
| (12) Electric saw | |

SUPERVISOR APPROVAL OF LESSON PLAN (PART II)

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ATC FORM APR 75 133 REPLACES ATC FORMS 337, MAR 73, AND 770, AUG 73, WHICH WILL BE USED.

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COURSE CONTENT

b. Working as a member of a six-man team and using course equipment and instructions provided by technical orders and check lists, perform preoperational inspections on various types of masonry tools and equipment. All work must be conducted in a safe manner and comply with the equipment's technical order. STS 6a(1), 6a(2), 6a(3), 10j(1), and 10j(2). Meas: W, PC (6/0)

(1) Concrete mixer

(2) Concrete saw

(3) Air compressor

(4) Paving breaker

(5) Pneumatic tamper

(6) Vibrator

(7) Power trowel

(8) Mortar mixer

(9) Tile saw

(10) Electric drill

(11) Electric saw

(12) Hand tools

(13) Electric hammer

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## SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SG 3ABR55233-I-8, Maintenance of Tools and Equipment
WB 3ABR55233-I-8-P1, Maintenance of Tools and Equipment
TO 32-1-101, Maintenance and Care of Hand Tools
TO 32-1-151, Hand Measuring and Power Tools
TO 32-1-171, Engineer Hand Tools
TO 32A9-2-6-14, Tamper, Backfill, Pneumatic, Worthington Model W-8
Manufacturer's Check Lists and Manuals

Training Equipment
Concrete Mixer (12)
Concrete Saw (12)
Air Compressor (12)
Paving Breaker (12)
Pneumatic Tamper (12)
Vibrator (12)
Power Trowel (12)
Mortar Mixer (12)
Tile Saw (12)
Electric Hammer (12)
Electric Drill (12)
Electric Saw (12)
Hand Tools for Masonry (2)

Training Methods
Discussion (4 hrs)
Demonstration (2 hrs)
Performance (6 hrs)

Multiple Instructor Requirements
Supervision (2)

Instructional Guidance
Use the T.O. file and have the students clean, sharpen, repair, maintain, and inspect all types of masonry tools and equipment. Divide the class into six-man teams during the practical work.

MIR: The class will be divided into two groups for the performance and will require one instructor for each group.

## PLAN OF INSTRUCTION/LESSON PLAN PART I

| NAME OF INSTRUCTOR | COURSE TITLE |
|---|---|
|  | Masonry Specialist |

| BLOCK NUMBER | BLOCK TITLE |
|---|---|
| I | Instroduction to Masonry |

| 1 COURSE CONTENT | 2 DURATION (Hours) |
|---|---|
| 9. Construction Layout | 14<br>(10/4)<br>Days 8 and 9 |
| a. Working as a member of a six-man team and using the assigned materials, area, hand tools, and workbook, lay out a building within a tolerance of plus or minus 1/4 inch.<br>STS 7a. Meas: W, PC<br>(1) Hub stakes<br>(2) Batter boards<br>(3) Layout lines<br>(4) Plumb bob<br>(5) Square<br>(6) Level<br>(7) Diagonal checking | (10/4) |

SUPERVISOR APPROVAL OF LESSON PLAN (PART II)

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ATC FORM APR 75 133 REPLACES ATC FORMS 337, MAR 73, AND 770, AUG 72, WHICH WILL BE USED.

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## SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SG 3ABR55233-I-9, Construction Layout
WB 3ABR55233-I-9-P1, Laying Out a Building for Masonry Construction

Audio Visual Aids
Transparencies, Construction Layout

Training Equipment
Hand Tools for Masonry (2)

Training Methods
Discussion (1 hr)
Demonstration (1 hr)
Performance (8 hrs)
Outside Assignment (4 hrs)

Multiple Instructor Requirements
Supervision (2)

Instructional Guidance
Explain the importance of correctly laying out a building. Discuss the methods and procedures of construction layout. Divide the class into six-man teams and have each team lay out a building. Observe each team very closely to make sure their procedures are correct. Make the following outside assignment: For day 8 have the students study SG 3ABR55233-I-9. For day 9 have the students review all the material covered in this block and be prepared for a test in day 9. The following references should be used in preparing the lesson. CDC 55233, Apprentice Mason, and AFP 88-27, Civil Engineer Handbook.

MIR: The class will be divided into two groups for the performance and each group will require one instructor.

10. Related Training (identified in the course chart) 14

11. Measurement Test and Test Critique 2

    a. Measurement Test

    b. Test Critique

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## PLAN OF INSTRUCTION/LESSON PLAN PART I

| | |
|---|---|
| NAME OF INSTRUCTOR | COURSE TITLE<br>Masonry Specialist |
| BLOCK NUMBER<br>II | BLOCK TITLE<br>Rigid Concrete Structures |

| 1 COURSE CONTENT | 2 DURATION (Hours) |
|---|---|
| 1. Concete Mixtures | 8<br>(6/2)<br>Day 10<br>(6/2) |

a. Working as a member of a four-man group, prepare concrete mixes in accordance with instructional material furnished by the instructor. All mixes must comply with given instructions. STS 9a(1) and 9e. Meas: W, PC

(1) Concrete ingredients

(2) Water-cement ratio (WCR)

(3) Concrete additives

(4) Factors affecting concrete strength

(5) Ingredients of standard concrete mixes

(6) Methods of preparing a standard concrete mix

(7) Slump test

(8) Safety precautions

SUPERVISOR APPROVAL OF LESSON PLAN (PART II)

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PLAN OF INSTRUCTION/LESSON PLAN PART I (Continuation Sheet)

COURSE CONTENT

## SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SG 3ABR55233-II-1, Concrete Mixtures
WB 3ABR55233-II-1-P1, Preparing Concrete Mixtures

Audio Visual Aids
Transparencies, Concrete Mixtures
Training Film: FLC-16/146, Principles of Quality Concrete

Training Equipment
Hand Tools for Mixing Concrete (2)

Training Methods
Discussion (1 hr)
Demonstration (1 hr)
Performance (4 hrs)
Outside Assignments (2 hrs)

Multiple Instructor Requirements
Supervision (2)

Instructional Guidance
Explain and demonstrate the methods of estimating the quantity of materials for concrete mixtures. Demonstrate the methods of mixing concrete and making a slump test. Divide the class into four-man groups and have them prepare a concrete mixture, and make a slump test. Make the following outside assignment: For day 10 have the students study SG 3ABR55233-II-1 and answer the questions at the end of the text. The following reference should be used when preparing the lesson: AFP 88-27, Civil Engineer Handbook.

MIR: The class will be divided into three groups during the performance. Two instructors will be required to supervise these three groups.

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## PLAN OF INSTRUCTION/LESSON PLAN PART I

| | |
|---|---|
| NAME OF INSTRUCTOR | COURSE TITLE<br>Masonry Specialist |
| BLOCK NUMBER<br>II | BLOCK TITLE<br>Rigid Concrete Structures |

| 1 COURSE CONTENT | 2 DURATION (Hours) |
|---|---|
| 2. Preparing for Concrete | 16<br>(12/4)<br>Days 11 and 12 |
| a. Prepare an area for a concrete slab within given specifications. The completed area must be smooth, compacted and ready for the construction of the forms. STS 6a(3) and 10b Meas: W, PC | (6/2) |
| (1) Compute the area to be concreted in square feet | |
| (2) Compute the amount of concrete needed | |
| (3) Tools required | |
| (4) Use of the pneumatic tamper | |
| (5) Site preparation | |
| (6) Checking the completed work | |
| b. Working as a member of a six-man team and using the instructions provided, build a form for concrete. The form must comply with the given instructions and be ready to receive the concrete mixture. STS 10a and 10b. Meas: W, PC | (6/2) |
| (1) Types and applications of forms | |
| (2) Tools and materials | |
| (3) Methods of building forms | |

SUPERVISOR APPROVAL OF LESSON PLAN (PART II)

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## SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SG 3ABR55233-II-2, Preparing for Concrete
WB 3ABR55233-II-2-P1, Preparing Site for Concrete
WB 3ABR55233-II-2-P2, Building Forms for Concrete
CDC 55233, Apprentice Mason

Audio Visual Aids
Transparencies, Preparing for Concreting
Transparencies, Building Forms
Training Film: FLC-8/88, How to Mix, Transport, Place, and Finish Quality Concrete

Training Equipment
Tractor Loader (12)
Tamper (12)
Hand Tools for Preparing Concrete (2)

Training Methods
Discussion (2 hrs)
Demonstration (2 hrs)
Performance (8 hrs)
Outside Assignment (4 hrs)

Multiple Instructor Requirements
Supervision (2)

Instructional Guidance
Discuss the purpose and advantage of adequately preparing the site for concreting. Explain the procedures for preparing the site. Divide the class into six-man teams and have each team prepare a site. Explain the types and construction features of forms. Divide the class into two groups and have each group build forms for concrete. Make the following outside assignments: For day 11 have the students study SG 3ABR55233-II-2. For day 12 have the students study paragraph 11, chapter 3 in CDC 55233. The following reference should be used when preparing the lesson: AFP 88-27, Civil Engineer Handbook.

MIR: For criterion objective 2b, the class will be divided into two groups. Each group will require one instructor.

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## PLAN OF INSTRUCTION/LESSON PLAN PART I

| NAME OF INSTRUCTOR | COURSE TITLE |
|---|---|
|  | Masonry Specialist |

| BLOCK NUMBER | BLOCK TITLE |
|---|---|
| II | Rigid Concrete Structures |

| 1 COURSE CONTENT | 2 DURATION (Hours) |
|---|---|
| 3. Reinforcement Materials and Tools | 8<br>(6/2)<br>Day 13 |
| a. Working as a member of a six-man team, measure, cut, and install wire mesh for a concrete slab. The wire mesh must fit correctly within the forms. STS 10c(3). Meas: W, PC<br>(1) Need for reinforcing concrete<br>(2) Reinforcement materials<br>(3) Tools and equipment<br>(4) Installation procedures | (2/1) |
| b. Tie and install reinforcement material to provide a bond between a concrete wall and slab. The reinforcement materials must fit correctly within the forms and the joint must be as strong as the rest of the structure. STS 10c(3) 10e, and 10j(3). Meas: W, PC<br>(1) Reinforcement joints in concrete<br>(2) Drilling holes in concrete<br>(3) Cutting reinforcement materials<br>(4) Installing reinforcement materials<br>(5) Tying reinforcement materials | (2/.5) |

SUPERVISOR APPROVAL OF LESSON PLAN (PART II)

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c. Fabricate a steel reinforcement section for a concrete column. The section must fit inside a frame 2 feet square and 4 feet high. STS 10c(1), 10c(2). Meas: W, PC (2/.5)

(1) Measuring reinforcement materials

(2) Cutting and bending reinforcement materials

(3) Installation procedures

## SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SG 3ABR55233-II-3 Reinforcement Materials and Tools
WB 3ABR55233-II-3-P1, Installing Reinforcement Material

Audio Visual Aids
Transparencies, Reinforcement Materials and Tools

Training Equipment
Bending Table (12)
Hand Tools for Installing Reinforcement Materials (2)

Training Methods
Discussion (1 hr)
Demonstration (1 hr)
Performance (4 hrs)
Outside Assignment (2 hrs)

Multiple Instructor Requirements
Supervision (2)

Instructional Guidance
Discuss the types and uses of reinforcement materials. Demonstrate how to measure, cut, bend and install reinforcement materials. Divide the class into two groups and have each group complete the workbook. Make the following outside assignment: For day 13 have the students study SG 3ABR55233-II-3 and answer the questions at the end of the text.

MIR: The class will be divided into two groups for the performance. Each group will require one instructor.

## PLAN OF INSTRUCTION/LESSON PLAN PART I

| NAME OF INSTRUCTOR | COURSE TITLE |
|---|---|
|  | Masonry Specialist |

| BLOCK NUMBER | BLOCK TITLE |
|---|---|
| II | Rigid Concrete Structures |

| 1 COURSE CONTENT | 2 DURATION ([illegible]) |
|---|---|
| 4. Mixing and Placing Concrete | 16<br>(12/4)<br>Days 14 and 15 |
| a. Working as a member of a six-man team and using the concrete mixer and required hand tools, mix, place and finish a concrete slab. Completed slab must be ready for the curing procedures. STS 6a(1), 9c(4), 10f(1), 10f(2), 10f(3), 10g(1), 10g(2), 10g(3), 10g(4), 10g(5), 10g(6), and 10g(7). Meas: W, PC<br>(1) Preoperational check of concreting equipment<br>(2) Safety precautions<br>(3) Concrete ingredients<br>(4) Mixing concrete<br>(5) Placing concrete<br>(6) Screed, float, and finish concrete | (6/2) |
| b. Working as a member of a six-man team, mix, place, and finish concrete for a wall structure. The completed structure must be ready for the curing procedures. STS 10d, 10e, and 10f(4). Meas: W, PC<br>(1) Types of mixtures required<br>(2) Tools and equipment<br>3) Mixing procedures |  (6/2) |

SUPERVISOR APPROVAL OF LESSON PLAN (PART II)

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PLAN OF INSTRUCTION/LESSON PLAN PART I (Continuation Sheet)

COURSE CONTENT

(4) Placing and finishing procedures

(5) Placement and use of anchor bolts

(6) Curing procedures

(7) Safety precautions

## SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SG 3ABR55233-II-4, Mixing and Placing Concrete
WB 3ABR55233-II-4-P1, Placing Concrete for a Slab
WB 3ABR55233-II-4-P2, Placing Concrete for a Wall
CDC 55233, Apprentice Mason

Audio Visual Aids
Transparencies, Concreting
Transparencies, Mixing and Placing Concrete in Wall Forms

Training Equipment
Concrete Mixer (12)
Power Trowel (12)
Vibrator (12)
Hand Tools for Mixing and Placing Concrete (2)

Training Methods
Discussion (2 hrs)
Demonstration (1 hr)
Performance (9 hrs)
Outside Assignment (4 hrs)

Multiple Instructor Requirements
Supervision (2)

Instructional Guidance
For criterion objective 4a explain the methods of mixing and placing concrete. Divide the class into two groups and have each group mix, place, and finish a concrete slab. For criterion objective 4b, explain and demonstrate how to mix, place, and finish concrete for a wall structure. Make the following outside assignments: For day 14 have the students study SG 3ABR55233-II-4 and answer the questions at the end of the text. For day 15 have the students study paragraphs 12 and 13, chapter 3 in CDC 55233.
The following reference should be used when preparing the lesson:
AFP 88-27, Civil Engineer Handbook.

MIR: The class will be divided into two groups for the performance and will require one instructor for each group.

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## PLAN OF INSTRUCTION/LESSON PLAN PART I

| | |
|---|---|
| NAME OF INSTRUCTOR | COURSE TITLE<br>Masonry Specialist |

| | |
|---|---|
| BLOCK NUMBER<br>II | BLOCK TITLE<br>Rigid Concrete Structures |

| 1 COURSE CONTENT | 2 DURATION (Hours) |
|---|---|
| 5. Curing Concrete | 8<br>(6/2)<br>Day 16 |
| a. Using given procedures, apply the material necessary to protect the concrete from extremes of weather and to effect a satisfactory cure of concrete slabs and structures. The applied materials must produce a satisfactory cure. STS 10i(1), 10i(2), and 10i(3). Meas: W, PC<br>(1) Concrete curing materials<br>(2) Reasons for curing concrete<br>(3) Methods of curing concrete<br>(4) Cold-weather concreting<br>(5) Hot-weather concreting | (6/2) |

SUPERVISOR APPROVAL OF LESSON PLAN (PART II)

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PLAN OF INSTRUCTION/LESSON PLAN PART I (Continuation Sheet)

COURSE CONTENT

## SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SG 3ABR55233-II-5, Curing Concrete
WB 3ABR55233-II-5-P1, Curing Concrete Slabs and Wall Structures

Audio Visual Aids
Transparencies, Curing Concrete

Training Equipment
Hand Tools for Curing Concrete (2)

Training Methods
Discussion (2 hrs)
Performance (4 hrs)
Outside Assignment (2 hrs)

Multiple Instructor Requirements
Supervision (2)

Instructional Guidance
Discuss the reasons for curing concrete. Name and explain the various ways of curing concrete. Divide the class into four-man groups and have them apply concrete curing materials. Make the following outside assignment: For day 16 have the students study SG 3ABR55233-II-5 and answer the questions at the end of the study guide.
The following reference should be used when preparing the lesson: AFP 88-27, Civil Engineer Handbook.

MIR: The class will be divided into three groups for the performance. Two instructors will be required to supervise these three groups.

## PLAN OF INSTRUCTION/LESSON PLAN PART I

| | |
|---|---|
| NAME OF INSTRUCTOR | COURSE TITLE<br>Masonry Specialist |
| BLOCK NUMBER<br>II | BLOCK TITLE<br>Rigid Concrete Structures |

| 1 COURSE CONTENT | 2 DURATION (Hours) |
|---|---|
| 6. Concrete Maintenance and Repairs | 22<br>(16/6)<br>Days 17, 18, and 19 |
| a. Using the prescribed tools and equipment and following given instructions, inspect and remove a damaged section of concrete and prepare the area for repair. Completed area must be ready for repairs. STS 10b, 10j(1), 10j(2), and 10j(3). Meas: W, PC<br>(1) Inspect defective concrete area<br>(2) Determine portion of concrete which must be removed<br>(3) Tools and equipment required<br>(4) Methods of removing damaged area<br>(5) Preparing the area for repairs<br>(6) Safety precautions | (6/2) |
| b. Using the prescribed tools and equipment and observing given requirements, mix, place, finish, and cure a concrete patch to the required specifications. Repaired patch must meet or exceed all required specifications. STS 9b, 9d, 10d, and 10h. Meas: W, PC<br>(1) Method of preparing subgrade and edge of old slab | (6/2) |

SUPERVISOR APPROVAL OF LESSON PLAN (PART II)

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PLAN OF INSTRUCTION/LESSON PLAN PART I (Continuation Sheet)

COURSE CONTENT

(2) Mixing procedures

(3) Placing procedures

(4) Finishing procedures

(5) Curing procedures

c. Following given instructions, remove, clean, and store concrete forms and finish the concrete surface to required specifications. The forms must be cleaned and stored correctly and the concrete surface must meet required specifications. STS 10h. Meas: W, PC (4/2)

(1) Form removal

(2) Cleaning, oiling, and storing of forms

(3) Slurry paste

(4) Finishing concrete surfaces

(5) Safety precautions

## SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
SG 3ABR55233-II-6, Concrete Maintenance and Repairs
WB 3ABR55233-II-6-P1, Repairing Damaged Concrete
WB 3ABR55233-II-6-P2, Remove Forms and Finishing Concrete Surfaces
CDC 55233, Apprentice Mason

Audio Visual Aids
Transparencies, Concrete Maintenance and Repairs

Training Equipment
Pavement Breaker (12)
Air Compressor (12)
Concrete Saw (12)
Hand Tools for Concrete Maintenance (2)

Training Methods
Discussion (5 hrs)
Performance (11 hrs)
Outside Assignment (6 hrs)

Multiple Instructor Requirements
Supervision (2)

Instructional Guidance
For criterion objectives 6a and 6b, discuss and demonstrate the methods of inspecting damaged or unsafe concrete. Divide the class into two groups and have each group remove and replace a section of damaged concrete. For criterion objective 6c, discuss and demonstrate the methods of removing forms, filling voids, finishing concrete surfaces, and cleaning and storing forms. Divide the class into two groups and have each group remove, clean and store concrete forms and finish the concrete surface. Make the following outside assignments: For day 17 have the students study SG 3ABR55233-II-6.
For day 18 have the students review chapter 1 in CDC 55233.
For day 19 have the students review all the material covered in this block and be prepared for a test.
The following references should be used when preparing the lesson: CDC 55233, Apprentice Mason, and AFP 88-27, Civil Engineer Handbook.

MIR: The class will be divided into two groups for the performance and each group will require one instructor.

7. Measurement Test and Test Critique 2

   a. Measurement Test

   b. Test Critique

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PREPARE THE MAN

STUDY GUIDE 3ABR55233-I-1 thru I-3
STUDY GUIDE 3ABR55233-I-5 thru I-9

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Department of Civil Engineering Training

Masonry Specialist

# INTRODUCTION TO MASONRY

5 July 1973

AIR TRAINING COMMAND

SHEPPARD AIR FORCE BASE

Designed For ATC Course Use

*DO NOT USE ON THE JOB*

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This supersedes the following:

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| SG 3ABR55233-I-1 | 15 March 1972 |
| SG 3ABR55233-I-2 | 10 March 1972 |
| SG 3ABR55233-I-3 | 17 January 1972 |
| SG 3ABR55233-I-5 | 15 March 1972 |
| SG 3ABR55233-I-6 | 3 March 1972 |
| SG 3ABR55233-I-7 | 31 January 1972 |
| SG 3ABR55233-I-8 | 5 January 1972 |
| SG 3ABR55233-I-9 | 1 March 1972 |

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# MODIFICATIONS

Pages 1-18 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

## SAFETY

### OBJECTIVE

To present information on some of the hazards present in accomplishing your duties as a member of the Air Force and the prescribed safety procedures you should follow to avoid personal injury or equipment damage.

### INTRODUCTION

As an Air Force specialist or technician, you should have two primary aims in life: one, to do a first class job in your assigned duty; the other, to return to civilian life, either by discharge or retirement, in as good a physical condition as possible. A thorough knowledge of the hazards confronting you, the established safety rules to protect you, and your observance of these safety rules, may determine what condition you will be in when you return to civilian life. In fact, it could determine whether or not you live long enough to become a civilian again.

The object of this study guide is to help you prevent injury or death to yourself or to your fellow workers, and to prevent damage or destruction of Air Force equipment.

Information on general safety practices is in SG AFS 54, 55, and 56, Safety. The safety practices pertinent to your specific job are covered here.

### Job Safety

Safety is a business. Accidents are costly. Money spent on materials and manpower for costly accidents is wasted. It cannot be redeemed. Even if no personal injury is involved, materials damaged by unsafe acts are costly to the Air Force.

Injury and material loss are only two of the many factors which are involved when an accident happens. Other factors are that the efficiency of the organization is affected, morale is affected, and if enough accidents happen it could impair the good relations between an organization and the community.

A standard dictionary defines the word "accident" as "an event that takes place without foresight or expectation." This definition means that with adequate foresight most accidents can be prevented. Only 2 percent of all accidents are caused by natural phenomena such as lightning, 10 percent are caused by physical hazards, and 88 percent are caused by unsafe acts of people. This is illustrated in figure 6.

You will be working with tools, equipment, and materials that you are not familiar with. Listed below are some of the safety precautions you should take while performing your job. If you are not familiar with the equipment or procedure you are to perform, check Air Force Manual 127-101, Accident Prevention Handbook, before proceeding.

TOOLS AND EQUIPMENT. Poor maintenance and the improper use of common hand and power tools result in many accidents which can be avoided if proper safety procedures are followed. One of the most abused rules in the use of tools is:

Use the right tool for the right job. Some additional rules that will help you be a safer workman are listed below:

a. Keep tools sharp.

b. Keep tools in their proper place.

c. Replace handles that become splintered or loose.

d. Dress mushroomed heads on cold chisels, punches, drift pins, etc. Figure 2A shows a chisel with a mushroomed head, and figure 7B, shows a chisel after the mushroomed head has been dressed.

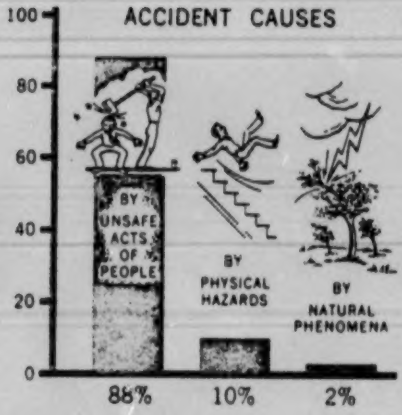


Figure 6. Accident Causes

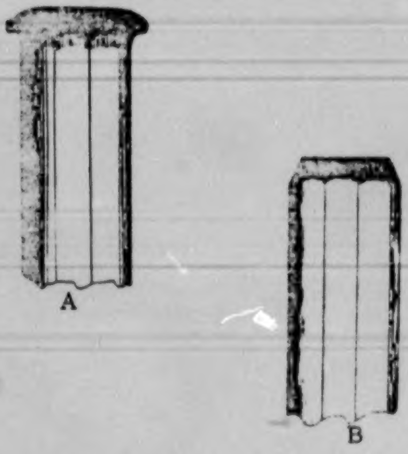


Figure 7. Dressing a Cold Chisel Head

e. Protect the edges of cutting tools with a sheath or by storing them separately from other tools.

f. Select a box end wrench or a socket in preference to an open end or an adjustable wrench as they are less likely to slip. To help prevent slippage, always pull the wrench toward you.

g. Wear goggles or face shields when there is possibility of flying chips, sparks, etc. Figure 8 shows a workman wearing eye protection properly.

h. Hold small items that are being worked on in a vise.

i. Never use a tool for anything other than what it is intended for: i.e., using a hammer handle for a pry bar, using a wrench for a hammer, using a knife for a screwdriver, or using a screwdriver for a pry bar, as shown in figure 9.

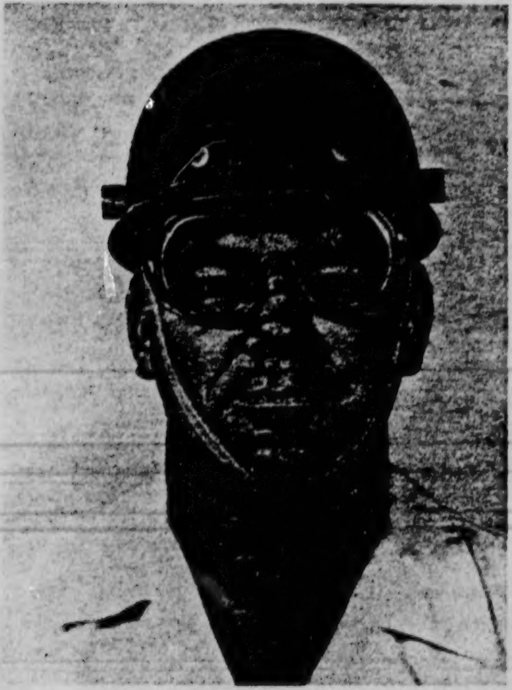


Figure 8. Correct Eye Protection

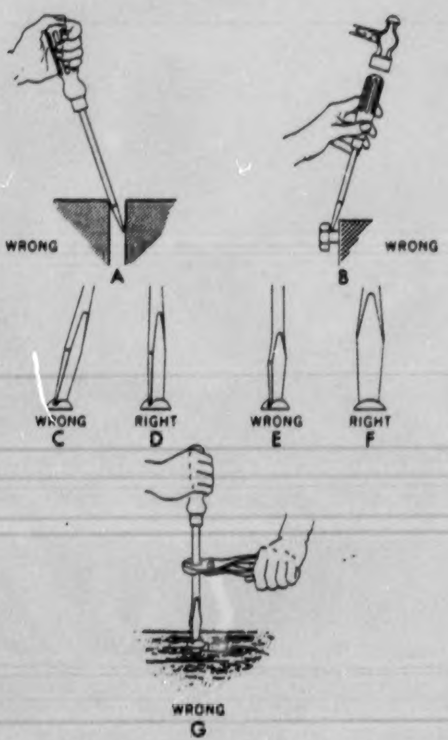


Figure 9. Use Screwdrivers Correctly

j. Use screwdrivers for what they are designed--to drive and remove screws. Note the right and wrong uses in figure 9. Keep the blades ground and shaped properly at all times. Select the proper type and size of screwdriver for the job. Never hold an object in one hand while working on it with a screwdriver. Place it in a vise.

k. Use files and rasps with handles that are designed for them. Without the proper handle, a file or rasp is dangerous because it is easy for the tang to injure the palm of your hand.

l. Keep chisels and punches clean and sharp because it is easy for a dull tool or dirty tool to slip and injure you.

LADDERS AND SCAFFOLDS. As a mason you will be required to work frequently from ladders and scaffolds. Working from a ladder or scaffold is much more hazardous than when you have both feet firmly on the ground or the floor of a building.

Ladders. There are many precautions that you must know to make it safer for you to be on ladders.

a. Always inspect ladders before use. Do not use a ladder that has a knot, check, split, or broken side rail or rung--condemn it!

b. Never stand on a ladder that is not placed on firm footing.

c. Be sure that the ladder is placed at a safe angle from the walls. A good rule to follow is to place the base of the ladder one-fourth as far out from the upper support as the length of the ladder, as shown in figure 10.

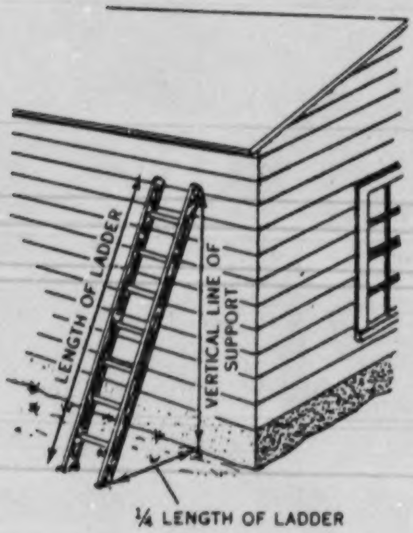


Figure 10. Correct Ladder Placement

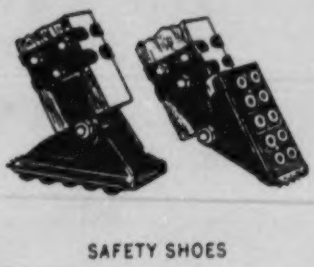


Figure 11. Ladder Safety Shoes

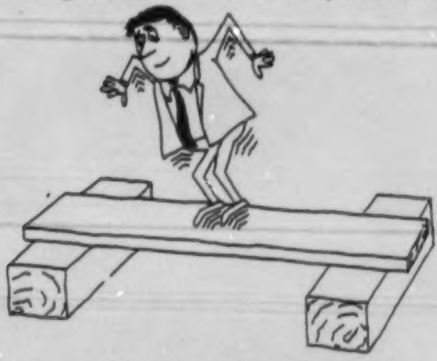


Figure 12. Pretesting Scaffolding

d. Never splice ladders together with wire, ropes, etc; use an extension ladder.

e. Pretest all ladders before using by placing horizontally with blocks under both ends and bouncing in the center.

f. When using extension ladders be sure they have a minimum overlap of at least 15 percent of their length for each section.

g. Rope off all doorways in front of a ladder and place warning signs. If any danger exists from slipping, tie the top of the ladder to the structure.

h. Use handlines to raise and lower tools and materials.

i. Do not overreach when working from a ladder. Move the ladder.

j. Never use metal ladders in areas where contact with electric powerlines is possible.

k. Do not use stepladders over 10-feet high. Never use one as a straight ladder. never stand on the top platform.

l. Safety shoes, as shown in figure 11, or spikes should be installed on the ends of ladders to keep them from slipping.

Scaffolds. Scaffolds, if erected properly, are considered safer and less tiring to work from than ladders. Listed below are some of the precautions you should be aware of while working from scaffolds.

a. Inspect all parts of a scaffold before use. Do not use it if the metal is damaged by corrosion or the wood parts have defects, such as checks, splits, unsound knots, or decay.

b. Before getting on a scaffold, check to make sure it is plumb and level. Compensate for unevenness of the ground by blocking or using adjusting screws.

c. If the scaffold is over 10 feet in height, anchor it to the wall. Be sure the braces fit and run diagonally.

d. Check the lumber and make sure the grain is straight. Be sure that no nailheads are protruding as you could trip over them or catch your clothes on them.

e. Provide guardrails, regardless of height, on the full length of the scaffold and also at the ends.

f. Use ladders when climbing scaffolds. Be sure they are erected with the ladders lined up from top to bottom.

g. Planking should have at least a 2-foot overlap. Never use planking for other purposes. Do not paint planking except on ends for identification.

h. Pretest all planking before using by placing it horizontally with blocks under both ends and bouncing in the center, as shown in figure 12.

HANDLING MATERIALS. The weight of a mason's tools and various materials often requires more than one man to lift. The Accident Prevention Handbook, AFM 127-101, recommends that objects weighing more than 50 pounds NOT be lifted by one person.

When lifting items use the proper lifting position, as shown in figure 13. This 50-pound maximum is only a suggestion; when it is necessary to lift an object and it "feels" heavy to you, use a mechanical lifting device or ask for help. Save your back!

ELECTRICAL HAZARDS AND PRECAUTIONS. You must be especially careful when working in an area where there is the possibility of contacting an electrical circuit. If an electric wire or cable is near your work area, it must be assumed that it is a "live" wire. Treat it with extreme care.

Electric tools and equipment will save you valuable time and make the job much easier for you. However, there is a hidden danger involved if the tool should develop a short circuit.

Frequently a newspaper somewhere tells of a workman being electrocuted while using a drill motor, powersaw, or other piece of electrical equipment. These deaths would probably not have happened if the workman had made sure the electrical tool was grounded properly.

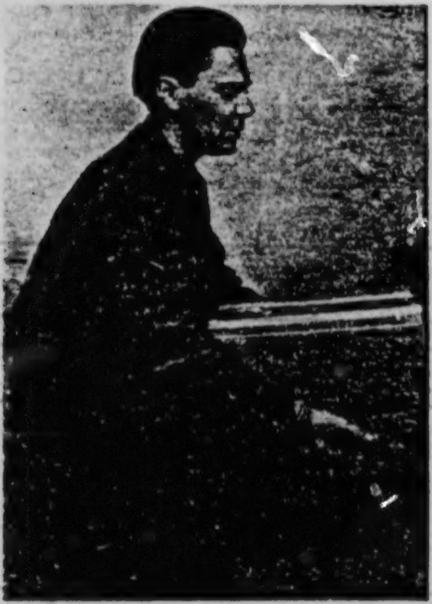


Figure 13. Proper Lifting Position

If a short develops in a tool and the cord is connected into a grounded receptacle, you will be safe.

If you use an extension cord, handle it so that the insulation does not become damaged. Dragging extension cords over sharp edges or rolling heavy trucks or materials over them, as shown in Fig. 15, damages the insulation and causes an unsafe condition. Do not pull on the cord to remove the plug from the outlet as it will loosen the connections and fray the wires, which could cause an unsafe condition.

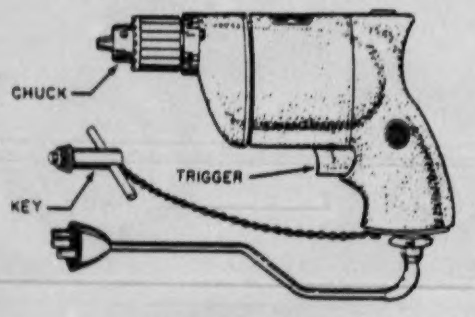


Figure 14. Electric Drill With Polarized Plug

Before you use a power tool, be sure it is equipped with a polarized (grounding) plug, as shown in figure 14, and a three-wire cord containing a grounding conductor (green). When you plug it in a receptacle, be certain that the receptacle is ~~also~~ grounded properly.

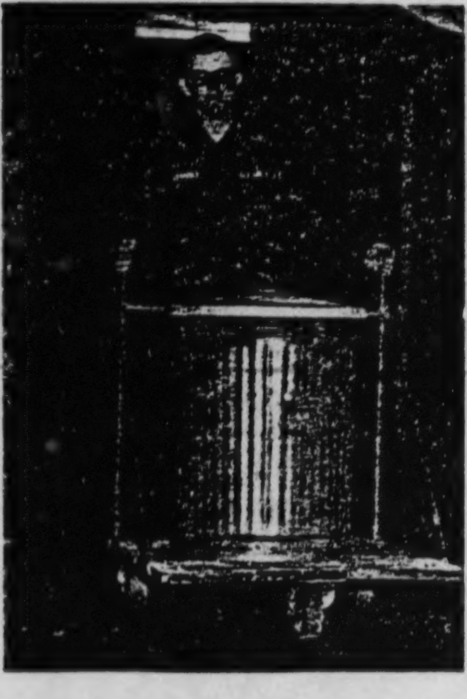


Figure 15. Do Not Damage Power Extension Cord

## LADDERS

Ladders are used to gain access to work which cannot be reached from the ground or floor level. You should use a ladder only in places where they can be used safely. This enables you to accomplish your work faster and much more comfortably than by using scaffolds.

### Types of Ladders

There are various types of ladders. Your job requires the use of single ladders, extension ladders, stepladders and trestle ladders.

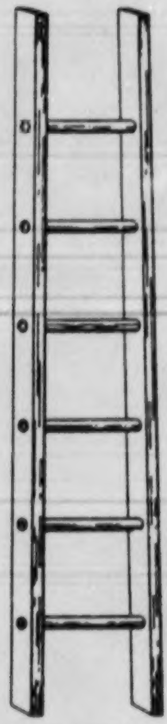


Figure 18. A Single Ladder

SINGLE LADDERS. This type of ladder consists of two side rails ranging from 8 to 30 feet in length and joined by steps (rungs) at 12-inch intervals. Single ladders may be constructed of wood or metal. A typical single ladder is shown in figure 16. The selection and use of a single ladder depends on the height at which you must work.

EXTENSION LADDERS. These ladders, as shown in figure 17, consist of two single ladders one of which slides in rail guides. This arrangement permits the ladder to be adjusted to different heights. They are equipped with two automatic locks, a metal shackle, pulley, and rope.

STEPLADDER. Figure 18 illustrates a stepladder which is intended to be used as a working platform at any one of its steps. Each step should afford a safe footing for the worker. Each step should be secured to the side rails. The locking device or spreader which holds the front and back sections apart should be of a positive action locking type.

TRESTLE LADDERS. Trestle ladders consist of two single ladders hinged at the top to form equal angles with the base. When two of these ladders are erected with a plank or extension platform extending between the rungs of the two ladders, the combination forms a painter's trestle as illustrated in figure 19. This type of ladder is useful on both interior or exterior work.

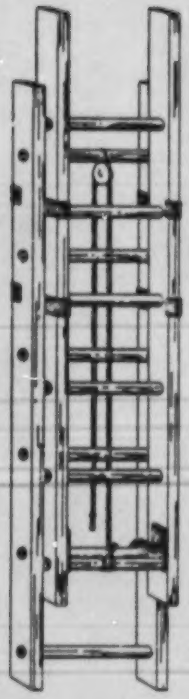


Figure 17. An Extension Ladder

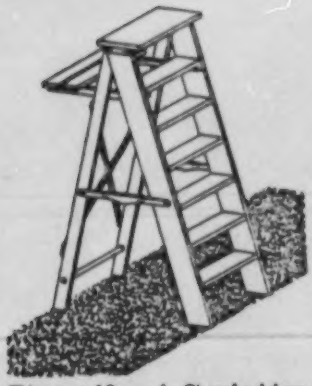


Figure 18. A Stepladder

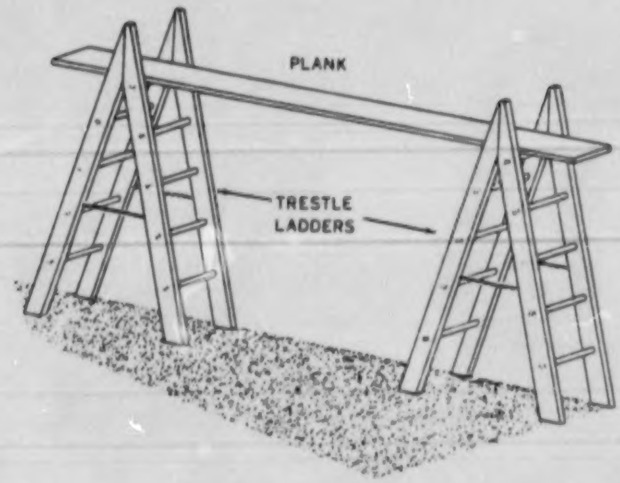

PLANK
TRESTLE LADDERS

Figure 19. A Painter's Trestle

## Safety Precautions When Using Ladders

The following safety precautions should be adhered to when using ladders.

1. Never use a single ladder over 30 ft long.
2. Extension ladders should never exceed 60 ft in length.
3. Stepladders should not be more than 20 ft high.
4. Store ladders in dry, warm areas.
5. Protect wooden ladders with clear coatings.
6. Straight and extension ladders must have safety shoes like those shown in figure 17.
7. Never use a ladder that has been spliced.
8. Never stand on top platform of a stepladder.
9. Never use metal ladders around electrical powerlines.
10. Never climb beyond the third rung from the top of a single or extension ladder.
11. Never slide down a ladder.
12. Do not climb a ladder with greasy or slippery shoes.
13. Never work more than one man at a time on a ladder.

## Erection Procedures for Ladders

There are many steps to remember when erecting ladders. Some of the most important are listed below.

1. Always perform a close inspection of the ladder before you use it.
2. Insure that the top of the ladder is against a firm support.
3. Insure that the base is on firm and level footing.
4. Never place a ladder in front of a door, aisle, or exit unless someone is at the bottom of the ladder to warn people.
5. The foot of a single or extension ladder should be a distance of about one-fourth (1/4) the length of the ladder from the structure (see figure 20).

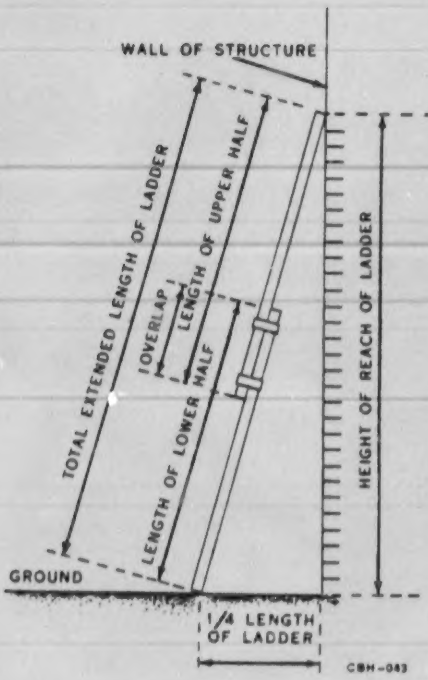

WALL OF STRUCTURE
TOTAL EXTENDED LENGTH OF LADDER
LENGTH OF UPPER HALF
OVERLAP
LENGTH OF LOWER HALF
HEIGHT OF REACH OF LADDER
GROUND
1/4 LENGTH OF LADDER
CBH-043

Figure 20. Ladder Stability

## SCAFFOLDS

Any framework which supports one or more platforms for workmen to stand or sit on when working at heights above floor or ground level is a scaffold.

Scaffolds made from dimensional lumber and usually constructed at the job site by carpenters are expensive to build, they are combersome and they are hard to move. They are generally out-dated and have been replaced by manufactured tubular steel or aluminum scaffolding.

Scaffolds are either fixed, portable, or suspended. The fixed and portable type scaffolds are self-supported. Suspended scaffolding is usually designed and used to reach very high surfaces.

### Types of Scaffolds

Our discussion will cover aluminum stairway scaffolds, adjustable metal scaffolds, ladder jack scaffolds, and swing stage scaffolds.

ALUMINUM STAIRWAY SCAFFOLDS. These scaffolds, as shown in figure 21, are strong, light in weight, and easy to handle. It can be set up by one man; no special tools are necessary. They are handy for exterior and interior work. They roll through doorways and fold for compact storage. This type of scaffolding comes in several sections.

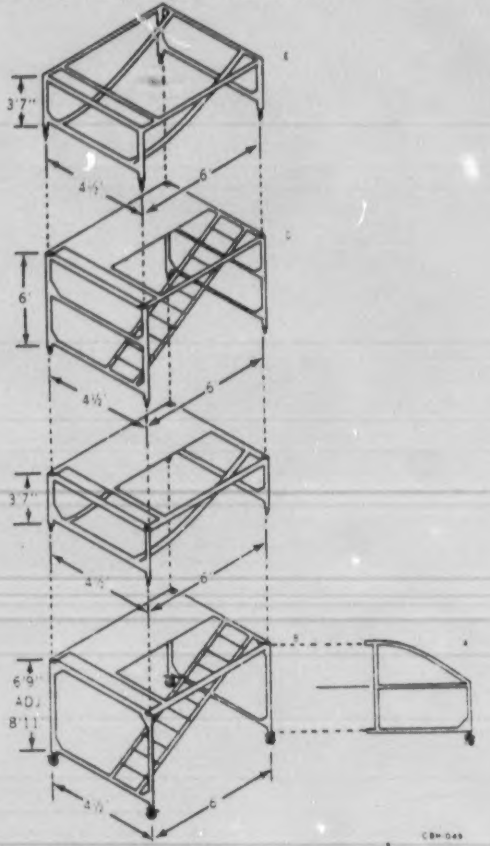

3'7"
4½'
6'
6'
4½'
6'
3'7"
4½'
6'
6'9"
ADJ
8'11"
4½'
6'
CBH-044

Figure 21. Aluminum Stairway Scaffold

The base (figure 21, section B) may be equipped with either one or two platform boards, usually two when only the base is used. The base is equipped with adjustable legs, as shown in figure 22, and locking casters, as shown in figure 23. Rolling outriggers can be installed when needed, see figure 24.

The half sections (figure 21, section C) may be used separately with the base section or in combination with a base section and an upper section (figure 21, section D) as the need arises. Install the guardrail (figure 21, section E) on the top section.

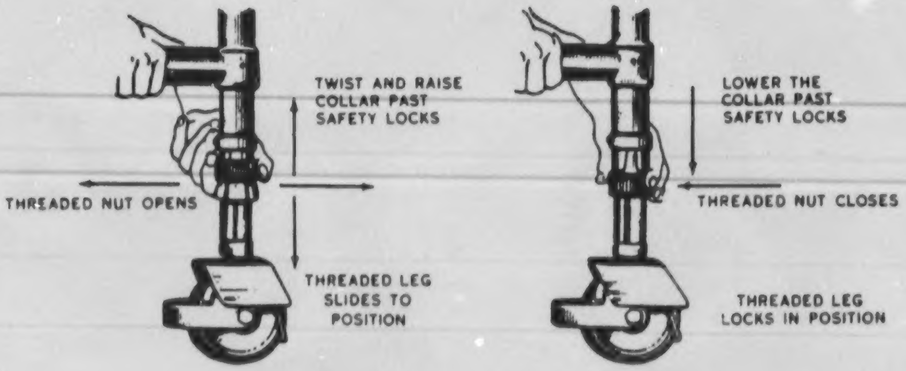
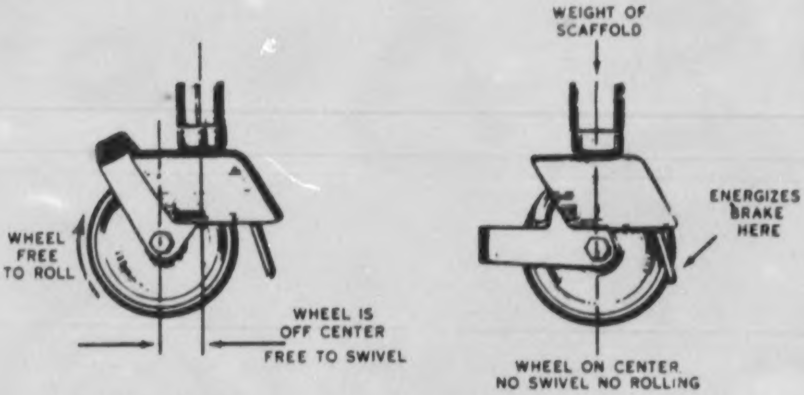

TWIST AND RAISE COLLAR PAST SAFETY LOCKS
THREADED NUT OPENS
THREADED LEG SLIDES TO POSITION
LOWER THE COLLAR PAST SAFETY LOCKS
THREADED NUT CLOSES
THREADED LEG LOCKS IN POSITION

Figure 22. Adjusting the Legs


WHEEL FREE TO ROLL
WHEEL IS OFF CENTER
FREE TO SWIVEL
WEIGHT OF SCAFFOLD
ENERGIZES BRAKE HERE
WHEEL ON CENTER
NO SWIVEL NO ROLLING

UNLOCKED

LOCKED

Figure 23. Locking the Wheels

ADJUSTABLE METAL SCAFFOLDS. Adjustable metal scaffolds made from tubular steel are strong, light in weight and have a low wind resistance, (see figure 25). These scaffolds are designed primarily for outside use. Assembly and dismantling is quicker and less hazardous than working with wooden scaffolding. Erect and dismantle these scaffolds according to the manufacturer's instructions.

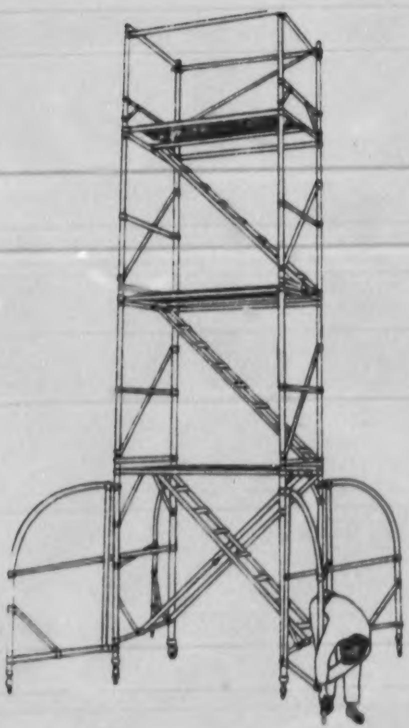


Figure 24. Installing Outriggers

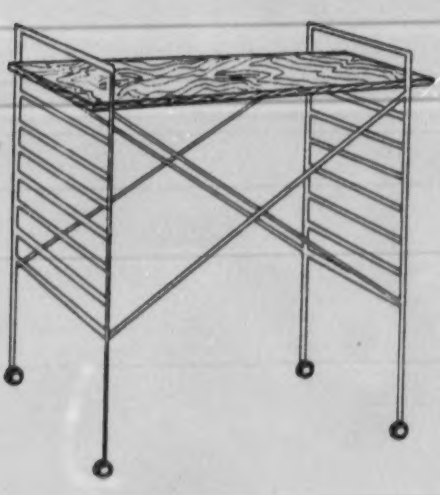


Figure 25. Adjustable Metal Scaffolds

SWING STAGE SCAFFOLD. The swing stage scaffold is different from either of the previous types discussed. It is used to reach upper surfaces of very high structures by suspending a platform from the roof or cornice as illustrated in figure 26. This scaffold is made up of several parts. They are named and pictured in figure 26. These units should be kept in perfect working condition at all times.

LADDER JACK SCAFFOLDS. Ladder jack scaffolds is a form of scaffold that enables you to work on a platform with safety, speed and comfort. By using two ladders, an extension plank, and two ladder brackets, like the one shown in figure 27. A scaffold can be erected quickly.

Scaffolds of various types are used in construction, repair, and maintenance of buildings and other structures. It is practically impossible for a workman to do satisfactory work at a height greater than 5 feet above the level on which he stands, without the use of a scaffold.

Types of Scaffolds

There are many types of scaffolds in common use. The types include single pole (where the wall supports one side), double or independent pole (where the scaffold stands by itself), tubular metal scaffold (commercially manufactured), suspended window jack, ladder jack, and horse scaffolds. Some of these are shown in figures 28 thru 32.

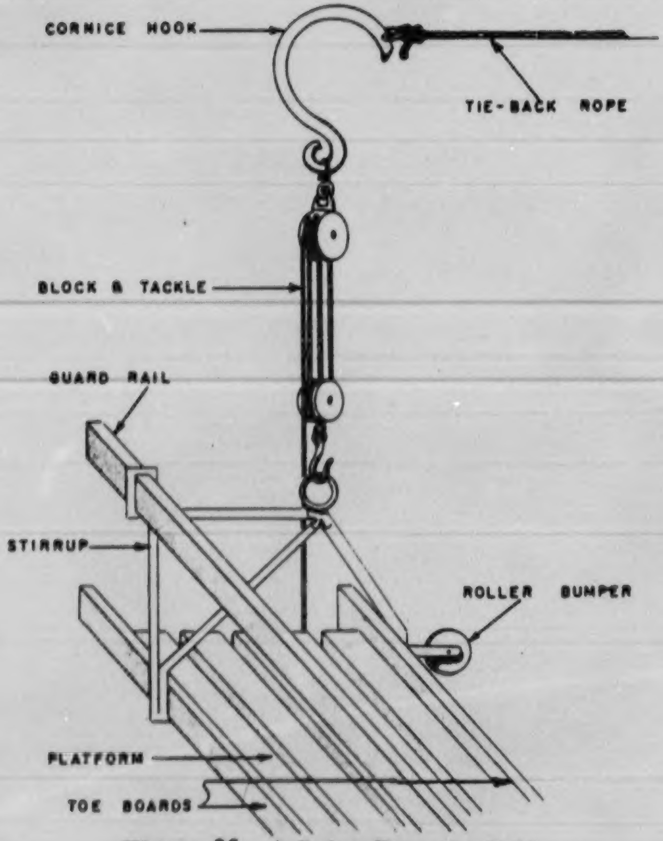

CORNICE HOOK
TIE-BACK ROPE
BLOCK & TACKLE
GUARD RAIL
STIRRUP
ROLLER BUMPER
PLATFORM
TOE BOARDS

Figure 26. A Swing Stage Scaffold

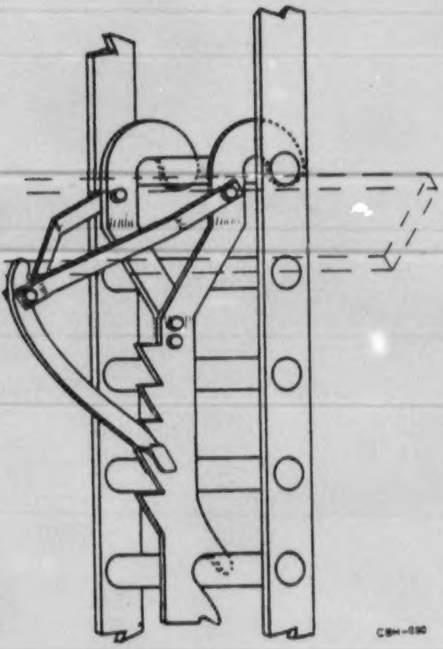


Figure 27. A Ladder Jack or Bracket

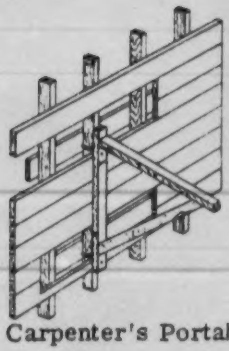


Figure 30. Carpenter's Portable Bracket

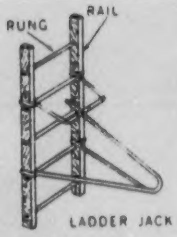

RUNG
RAIL
LADDER JACK

Figure 31. Ladder Jack

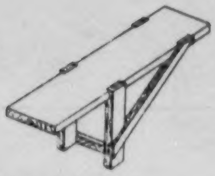


Figure 28. Window Jack

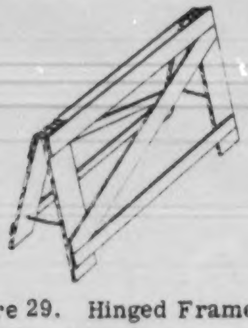


Figure 29. Hinged Frame Horse

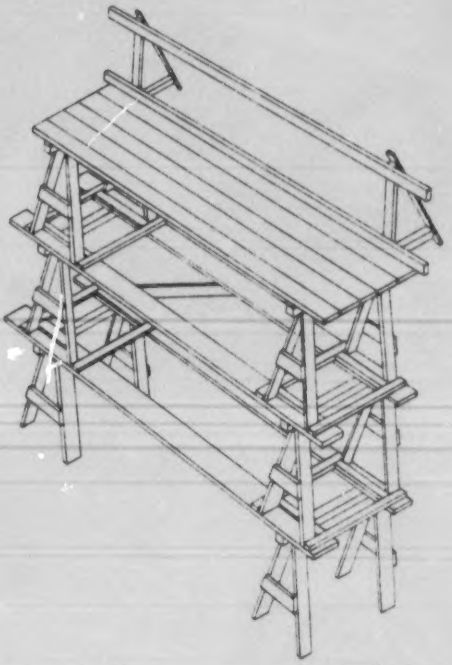


Figure 32.

## When Using Scaffolding

The following safety steps should be adhered to when using tubular type scaffolding:

1. All parts of any scaffold must be constructed or erected to provide an ample factor of safety under full loads.
2. Scaffolds must be inspected and kept in safe condition at all times.
3. Each scaffold should be provided with a safe means of access, either by stairway or a properly secured ladder.
4. The casters on portable scaffolds should be locked when the scaffold is in its proper position.
5. Never stand under scaffolding when it is in use.
6. Use outriggers when the scaffold exceeds three sections.
7. If scaffold is over 40 feet, use properly anchored guy wires or tie the scaffold to the structure.

The following safety precautions should be adhered to when using swing stage scaffolds:

1. After erecting a swing stage scaffold, hoist it one foot off the ground and test it with four times the working load.
2. Lash the swing stage to the building or structure after hoisting to keep it from swinging outward.
3. Use wire cables for hoisting equipment when working with acid solutions.
4. Swing stage scaffolds not in use should be lowered to the ground for safety reasons.
5. When raising a swing stage scaffold, keep the weight on the outside of the platform until the swing stage is secured to the building.
6. Make it a rule never to touch the wall next to a swing stage until it is secured to the building. A light push against the wall may swing the stage out so that one or more painters may lose their balance and fall.
7. Inspect and perform necessary maintenance on all hoisting equipment before using.
8. Tackle block rope will be stored in a dry place.
9. Tackle block rope should not be permitted to scrape against sharp projections.
10. Rope under heavy loads must not be pinched between hard surfaces.
11. Inspect all planks which are used as a part of a swing stage scaffold.

12. Safety belts and lifelines will be worn when a man is required to work on high scaffolds. The lifeline attached securely to the building should be only long enough to permit the masonry specialist to reach the working surface. Should he fall, the lifeline will keep him from falling any great distance, see figure 33.

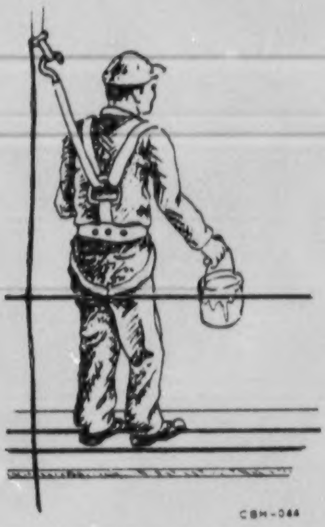


Figure 33. Safety Belt and Lifeline

SUMMARY

Safety is your business. It means your career and, sometimes, your life. Before starting your jobs, determine whether or not you can accomplish the specific tasks safely.

QUESTIONS

1. Name four types of ladders.
2. When should a ladder be used?
3. What is the rule for properly placing a ladder against a wall?
4. What type of finish should be applied to wooden ladders?
5. What are the advantages of aluminum and steel tubular scaffolding over wood type?
6. When should outriggers be installed on aluminum scaffolds?
7. What is the purpose of a lifeline?
8. What are the two main reasons for accidents with tools?
9. What should be done with a cold chisel that has a "mushroomed" head?

10. Which type of wrench is the safest to use?

11. How should you hold an object from which you are removing a screw?

12. What should you do with a ladder that has a broken rung in it?

13. How far from a building should the base of a ladder be placed?

14. Before you use a new ladder, what should you do with it?

15. If you must work on a ladder in front of a doorway, what precaution should you take?

16. Which is the safest to work from, a scaffold or a ladder?

17. What should you do to a scaffold that is 20-feet high?

18. What should you use to climb a scaffold?

19. If you are going to use a new plank, what should you do?

20. According to the Accident Prevention Handbook, you should have help when lifting objects that weigh over how many pounds?

21. What is the purpose of grounding a power tool?

22. What precaution should be taken prior to using any electrically powered drill motor?

## REFERENCES

1. AFM 127-101, Industrial Safety Accident Prevention Handout

2. CDC 55253, Masonry Specialist

54

## MATHEMATICS AND ESTIMATING

## OBJECTIVE

To present a review of simple math as used in the masonry field.

## INTRODUCTION

This study guide covers arithmetic, the first branch of mathematics. Here you will review the four basic operations: addition, subtraction, multiplication, and division. It includes the study of numbers and the methods used to compute or solve problems with quantities expressed by numbers.

### WHOLE NUMBERS

Whole numbers represent complete units. The whole number, 1, represents one complete unit; 2, represents two complete units; 3, represents three; and so on. As an example, the whole number, 6,836, represents six thousand, eight hundred, and thirty-six complete units.

Commas separate the major groups when used in whole numbers. The whole number twenty-nine million, seven hundred forty-five thousand, one hundred sixty-three is written as 29,745,163.

### FUNCTIONS INVOLVING WHOLE NUMBERS

#### Rounding Off

Rounding off a whole number expresses the number in a shortened or condensed form to the nearest whole number. When rounding off a whole number, first determine the place to which you want to round off. Then look at the number directly to the right of the desired place. If it is 5 or more, the place becomes a number with a value of 1 more added to it. When the number to the right of the place is less than 5, then the value of the desired place number remains unchanged.

Examples:

(1) 475, rounded off to tens = 480
(2) 474, rounded off to tens = 470

## Math Operation Signs

Math operation signs are frequently used to indicate the desired operation on a set of numbers. The signs of operation are: + (plus) for addition, − (minus) for subtraction, x for multiplication, and ÷ for division.

Some problems may contain two or more different signs of operation. These are solved by closely following a specified order of operation:

First - Multiply
Second - Divide
Third - Add
Fourth - Subtract

Example:

(Problem)

5 + 3 x 4 - 16 ÷ 2

(Solution)

(1) 5 + 12 − 16 ÷ 2

(2) 5 + 12 − 8

(3) 17 − 8 = 9

## Addition

The addition of whole numbers is the operation of combining numbers to obtain an equivalent simple quantity. The numbers that are being added are called addends. The answer arrived at by the addition of numbers is called the sum. Columns of numbers being added together must be properly lined up from right to left; ie, units must be under units, tens under tens, etc.

Example:

| | | |
|---|---|---|
| (1) | 21,492 | Addend |
| | 7,618 | Addend |
| | 537 | Addend |
| | + 16 | Addend |
| | 29,663 | Sum |

(2) 673 + 158 = 831

(3) 16 + 21 + 3 = 40

Addition is used to compute the total quantity of material needed for the completion of a work order or project.

## Subtraction

The subtraction of whole numbers is the operation of deducting or taking away one number from another. The parts in a subtraction problem are the minuend, subtrahend, and the remainder. The minuend is the larger number or the number you are subtracting from. The subtrahend is the smaller number that is being subtracted from the larger number. The remainder is the number left, which is the answer to the problem.

Examples:

(1) 1,694 Minuend
- 819 Subtrahend
875 Remainder

(2) 975 - 974 = 1

(3) 1,694 - 819 = 875

Subtraction is used to compute the quantity of material remaining after completing a work order. It can also be used to insure sufficient material is on hand to complete a project.

## Multiplication

Multiplication of whole numbers is the operation that, at its simplest, is an abbreviated process of adding a number to itself a specified number of times. Multiplication problem parts are multiplicand, multiplier, and product. The multiplicand is a number that is to be multiplied by another number. The multiplier is the number doing the multiplying. The product is the answer.

Examples:

(1) 6 Multiplicand
x 3 Multiplier
18 Product

(2) 37
x 25
185
x 74
925

(3) 6 x 3 = 18

(4) 37 x 25 = 925

Multiplication is used to compute the quantity of material needed for a job, the area of a surface, the volume of material to be removed or placed, total man-hours of labor, etc.

## Division

The division of whole numbers is the operation of finding how many times one number or quantity is contained in another. In division, the name of the parts are divisor, dividend, quotient, and remainder. The dividend is the number or quantity that is being divided, and the divisor is the number that is divided into the dividend. The quotient is the answer. The divisor and quotient are factors of the dividend. If the division does not come out evenly and there is a quantity left over, that quantity is called the remainder.

Example:

(a) Factors

28 Quotient
Divisor 13)376 Dividend
26
116
104
12 Remainder

(2) 24 ÷ 6 = 4

(3) 144 ÷ 12 = 12

Division is used whenever you need to know how many times a quantity is contained in another. One instance could be the number of cubic yards contained in a volume of cubic feet when ordering ready-mix concrete. Here, you would divide 27 into the total number of cubic feet and the answer would be the number of cubic yards of concrete needed for the job. One cubic yard contains 27 cubic feet.

## PROBLEM SOLVING

### Addition

Any problem in addition, subtraction, multiplication, or division must be set up correctly in order to solve it correctly. In addition, you must put like-units under like-units. Example: To add 691 + 8 + 73 + 309:

| WRONG | RIGHT |
|---|---|
| 691 | 691 |
| 8 | 8 |
| 73 | 73 |
| + 309 | + 309 |
| 15,319 | 1,081 |

### Subtraction

In subtraction, like units go under like units, but the smaller number is placed under the larger number. Example: To subtract 837 from 984:

| WRONG | RIGHT |
|---|---|
| 837 | 984 |
| − 984 | − 837 |
| 153 | 147 |

### Multiplication

In multiplication the smaller number should be placed on the bottom. Example: To multiply 1,298 by 42:

| WRONG | RIGHT |
|---|---|
| 42 | 1,298 |
| x 1,298 | x 42 |
| 336 | 2596 |
| 378 | 5192 |
| 84 | 54,516 |
| 42 | |
| 840 | |

**Division**

In division, the dividend goes inside the division block while the divisor is placed outside. Example: To divide 1092 by 13:

| WRONG | RIGHT |
|---|---|
| $1092\overline{)13}$ | $\begin{array}{r}84\\13\overline{)1092}\end{array}$ |

## COMMON TERMS

Common terms must be used before any mathematical operation can be performe A problem involving feet and inches must be converted to inches only. Cubic yards m be required in place of cubic feet, square yards instead of square feet, etc. In other words, common terms must be the same term applied to all factors (addends, divisors subtrahends, multipliers, etc) involved in a problem.

## FRACTIONS

A fraction is a numerical representation of two numbers whose quotient is to be determined. A whole number that has been fractionalized is broken or divided up into separate parts or sections. One (1) divided into two equal parts becomes two halves (2/2). Each of these two parts is represented by the fraction 1/2. To prove this: 1/2 + 1/2 = 2/2 or 1. This principle can be applied to all whole numbers.

Examples: (Each part name, with symbol)

(1) 1 = 1/1
(2) 2 = 2/2 (one-half, 1/2)
(3) 3 = 3/3 (one-third, 1/3)
(4) 4 = 4/4 (one-quarter, 1/4)
(5) 5 = 5/5 (one-fifth, 1/5)
(6) 6 = 6/6 (one-sixth, 1/6) . . . (etc)

## TYPES OF FRACTIONS

There are four types of fractions: common, improper, mixed, and decimal. This section contains information on the first three (the decimal fraction will follow).

### Common Fraction

The common fraction consists of two numbers, one above the other, separated by a dividing line. The number above the line is the numerator and the number below the line is the denominator. The numerator is a smaller number than the denominator.

Example: $\frac{1}{2}$ $\begin{array}{l}\text{(numerator)}\\\text{(denominator)}\end{array}$

### Improper Fraction

An improper fraction consists of two numbers, one above the other, with a numerator larger than the denominator.

Examples: (1) $\frac{3}{1}$

(2) $\frac{16}{9}$

### Mixed Fraction

The mixed fraction consists of a whole number in front of a common fraction. Its total value is the same as an improper fraction of equal value.

Examples: (1) 2 1/2 = $\frac{5}{2}$

(2) 1 2/3 = $\frac{5}{3}$

(3) 7 5/12 = $\frac{89}{12}$

## FUNCTIONS INVOLVING FRACTIONS

### Preliminary Preparation

Preliminary preparation of fractions is the work done before a problem can be solved. This is similar to the use of common terms, which must be used in all mathematical problem solving.

### Reducing a Fraction

Reducing a fraction means to change a large fraction to a smaller fraction with the same value. This is done by dividing a number equally into the numerator and denominator.

Examples: (1) $\frac{5}{10} = \frac{1}{2}$ (dividing each by 5)

(2) $\frac{12}{27} = \frac{4}{9}$ (dividing each by 3)

A common denominator means that the denominator is the same in all fractions in a problem. To change a fraction to a common denominator, divide the denominator into the proposed or desired common denominator and then multiply both numbers of the fraction by this quotient.

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Example:

| **BEFORE** | **AFTER** |
|---|---|
| $\frac{1}{2} + \frac{5}{6} + \frac{3}{4}$ | $\frac{6}{12} + \frac{10}{12} + \frac{9}{12}$ |

The Process of Cancellation

The process of cancellation means to simplify all fractions in a multiplication problem by all possible division. Be extremely careful in this process because the value of the fractions must not be changed. It is possible and permissible to cancel diagonally as well as straight up and down.

Examples:

(1) $\frac{\overset{7}{\cancel{14}} \times \overset{5}{\cancel{15}}}{\underset{4}{\cancel{8}} \times \underset{3}{\cancel{9}}}$ becomes $\frac{7 \times 5}{4 \times 3}$

(2) $\frac{\overset{9}{\cancel{27}} \times \overset{1}{\cancel{4}}}{\underset{3}{\cancel{12}} \times \underset{5}{\cancel{15}}}$ becomes becomes $\frac{3 \times 1}{1 \times 5}$ finally $\frac{3 \times 1}{1 \times 5}$

Changing a Mixed Fraction

It is necessary to change a mixed fraction to an improper fraction in problems involving multiplication and division. Multiply the whole number by the denominator and add the numerator to the product. This will be the numerator of the improper fraction, while the denominator remains the same.

Examples: (1) $6\frac{1}{2}$ becomes $\frac{13}{2}$

(2) $3\frac{7}{8}$ becomes $\frac{31}{8}$

Addition

The addition of fractions is similar to that of whole numbers. First, a common denominator must be obtained. Then, add all numerators together, leaving the common denominator alone.

Examples: (1) $\frac{1}{2} + \frac{2}{5} = \frac{5}{10} + \frac{4}{10} = \frac{9}{10}$

(2) $\frac{3}{8} + \frac{1}{3} + \frac{3}{4} = \frac{9}{24} + \frac{8}{24} + \frac{18}{24} = \frac{35}{24} = 1\frac{11}{24}$

### Subtraction

Subtraction of fractions is similar to that of whole numbers. Just as in addition, a common denominator must be selected. The smaller fraction is placed below the minuend or after the minus sign (–).

Examples:

(1)

| BEFORE | AFTER |
|---|---|
| $\frac{7}{8}$ | $\frac{7}{8}$ |
| $-\frac{3}{4}$ | $-\frac{6}{8}$ |
| | $\frac{1}{8}$ |

(2) $\frac{1}{2} - \frac{1}{4} = \frac{2}{4} - \frac{1}{4} = \frac{1}{4}$

### Multiplication

The multiplication of fractions requires a preliminary step before solving. First, the process of cancellation must be carried out. The next step is to multiply all numerators together and place the product as the numerator of the answer. Then, multiply the denominators together and place this product as the denominator of the answer.

Examples:

(1) $$\frac{\overset{1}{\cancel{3}} \times \overset{2}{\cancel{8}}}{\underset{1}{\cancel{4}} \times \underset{3}{\cancel{9}}} = \frac{1 \times 2}{1 \times 3} = \frac{2}{3}$$

(2) $$\frac{\overset{1}{\cancel{2}} \times \overset{1}{\cancel{4}} \times \overset{1}{\cancel{3}}}{\underset{1}{\cancel{3}} \times \underset{3}{\cancel{12}} \times \underset{3}{\cancel{6}}} = \frac{1 \times 1 \times 1}{1 \times 3 \times 3} = \frac{1}{9}$$

### Division

Division of fractions is the most complex of all operations involving fractions. Actually, the process of division, as in whole numbers, is not carried out. Instead, the divisor is inverted and the problem is solved by multiplication. Therefore, you must be sure that you invert the divisor and not the dividend.

Examples:

(1) $\frac{3}{8} \div \frac{1}{2} = \frac{3}{8} \times \frac{2}{1} = \frac{6}{8} = \frac{3}{4}$

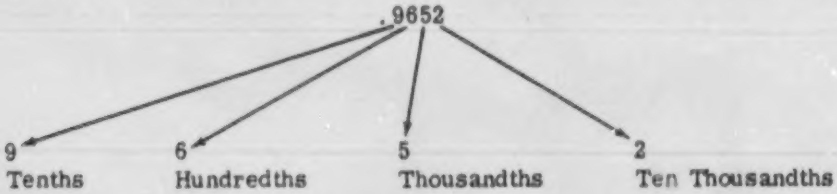
(2) $\frac{11}{16} \div \frac{7}{8} = \frac{11}{\underset{2}{\cancel{16}}} \times \frac{\overset{1}{\cancel{8}}}{7} = \frac{11}{2} \times \frac{1}{7} = \frac{11}{14}$

# DECIMALS

A decimal is a number that represents a fraction with a denominator that is a power of ten. Being a power of ten means that you can divide ten into the number evenly. The fraction 63/100 has a denominator of one hundred and ten will divide evenly into it.

All decimals represent fractions and in every case the denominator is a power of ten. The decimal .1 represents the fraction 1/10; the decimal .39 represents 39/100.

Each digit in a decimal has a place value and is read in a specific way. The example shown below is read nine thousand, six hundred fifty-two ten thousanths.



When there is a whole number and a decimal, the decimal point is read "and." Example: 9.21 is read "nine and twenty-one hundredths."

The place value of decimals is very important. This indicates the number of digits needed to the right of the decimal point. Six thousandths requires three digits because it is to the thousandths place and is written as .006.

A fraction can be changed into a decimal. The numerator is divided by the denominator after placing the decimal point immediately to the right of the numerator. Add as many zeroes to the right of the decimal as needed. Place a decimal point in the quotient directly over the decimal point in the dividend.

Examples: (1) Change 5/8 to a decimal

$$\begin{array}{r} .625 \\ 8\,\overline{)\,5.000} \end{array}$$

(2) Change 8/5 to a decimal

$$\begin{array}{r} 1.6 \\ 5\,\overline{)\,8.0} \end{array}$$

A decimal can be changed into a fraction. The digits of the decimal become the numerator of the fraction. The denominator of the fraction will have a one, followed by the same number of zeroes as the digits in the decimal.

Examples:

(1) .31 becomes 31/100
(2) .979 becomes 979/1000
(3) 2.3 becomes 2 3/10
(4) .035 becomes 35/1000 or 7/200

A large, cumbersome decimal may be made smaller and easier to use. In cases where a great amount of accuracy is not important, you may round off the decimal.

Look at the digit directly to the right of the desired place. If that digit is 5 or more, add one to the desired place and drop the remainder of the numbers. When the number is less than 5, leave the place value as is and drop the remainder of the numbers.

Examples: (1) Round off .26498 to nearest hundredth .26

(2) Round off .0839 to nearest tenth .1

Addition of Decimals

The addition of decimals is almost the same as with whole numbers. The only difference is that you must keep the decimal points lined up in a vertical column. The decimal point is brought down vertically into the sum.

Examples:

(1)
$$\begin{array}{r} 6.03 \\ .917 \\ 75.2 \\ +\ \ .008 \\ \hline 82.155 \end{array}$$

(2)
$$\begin{array}{r} 17.378 \\ .00025 \\ +\ 6399.4\phantom{0000} \\ \hline 6416.77825 \end{array}$$

Subtraction of Decimals

The subtraction of decimals follows the same rules as in whole numbers. The smaller number always goes under the larger with the decimal points lined up vertically.

Examples:

(1)
$$\begin{array}{r} 367.984 \\ -249.26\phantom{0} \\ \hline 118.724 \end{array}$$

(2)
$$\begin{array}{r} 198.74\phantom{0} \\ -\ 82.657 \\ \hline 116.083 \end{array}$$

Multiplication of Decimals

Decimals are multiplied just like the whole numbers, with a decimal point placed in the product. After the multiplication operation is completed, count the total number of digits to the right of the decimal point in both the multiplicand and the multiplier. Then, count off that many places from the right in the product and place a decimal point at that exact spot.

Examples:
$$\begin{array}{r} 21.73 \\ \times\ .32 \\ \hline 4346 \\ 6519\phantom{0} \\ \hline 6.9536 \end{array}$$

(2)
$$\begin{array}{r} 6.001 \\ \times\ 1.9 \\ \hline 54009 \\ 6001\phantom{0} \\ \hline 11.4019 \end{array}$$

### Division of Decimals

The division of decimal numbers is more difficult. The most important rule to remember is that the divisor must be made a whole number before starting to divide. Move the decimal point all the way to the right. Then move the decimal in the dividend the same number of places to the right, adding zeroes if necessary, to obtain the correct number of places.

Examples:

(1) BEFORE .65 ) 896.427 AFTER 65. ) 89642.7

(2) BEFORE 2.5 ) 75 AFTER 25. ) 750.

When the divisor is a whole number and the dividend is a decimal, do not move the decimal point. In all cases of division, place the decimal point in the quotient directly above the decimal point in the dividend and then proceed to divide as you did with whole numbers

Examples:

$$\begin{array}{r} \downarrow \\ 12.98 \\ 16\,\overline{)\,207.68} \end{array}$$

## PERCENTAGE

Percentage is defined as a part of a whole expressed in hundredths. Percent is reckoned on the basis of a whole divided into one hundred parts. Each of these parts is identified as one percent (1%) of the whole. The value of 1% is equal to 1/100 or .01 of the whole; 78% is equal to 78/100 or .78; etc.

A decimal number can be changed to percent. First, move the decimal point two places to the right. Then add the percent sign (%) after the number.

Examples:

(1) .67 = 67%
(2) .03 = 3%
(3) .259 = 25.9%
(4) .8 = 80%
(5) 1.93 = 193%

Percent can be changed to a decimal. Drop the percent sign and move the decimal point two places to the left.

Examples:
(1) 29% = .29
(2) 13.7% = .137
(3) 2.68% = .0268
(4) .5% = .005
(5) 1/4% = .0025

## BASIC MEASUREMENTS

### Linear

What is linear measurement? Linear means "in a straight line." So linear measurement means measuring something straight. If you measure the length of a board or width of a cut or depth of a basement, you are making a linear measurement.

The procedure to change a percent to a common fraction is more complex. First, change the percent to a decimal. Second, change the decimal to a fraction. Third, reduce the fraction to its lowest terms.

Example: 50% = .50 = 50/100 = 1/2

Reverse the above procedure to change a fraction to a percent. First, change the fraction to a decimal. Then change the decimal to percent.

Examples:

(1) 1/2 = .50 = 50%

(2) 3/8 = .375 = 37.5%

Percentage problems can be solved by substituting given information into a formula. The formula is given below:

$$\frac{\text{SMALL NUMBER}}{\text{LARGE NUMBER}} = \frac{\%}{100\%}$$

When using this formula, be sure to set up the numbers correctly. Percentage numbers all go on the right side of the equal sign and all other information numbers are placed on the left side.

Example:

(Problem) Out of 80 sacks of cement used last week, 7 sacks were torn. What was the percent of torn sacks?

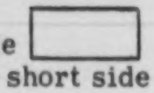
(Formula set-up)

$$\frac{7}{80} = \frac{x\%}{100\%}$$

After the formula has been set up, continue then solve the problem.

(Solution)

$$\frac{7}{80} = .0875 = 8.75\%$$

To measure a rectangle  , you would need to make only two linear measurements: one short side and one long side. How many linear measurements do you need to make on a square?

Linear measurements are made to find length, width and height.

Square

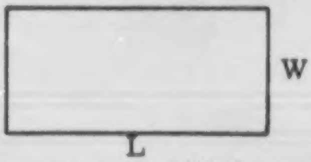
Much masonry work is estimated on square footage of material. A square foot is the area that is one foot long and one foot wide. An area that is one foot wide and two feet long contains two square feet.

Square feet of an area can be found by multiplying length times width. How many square feet are there in an area 6 feet wide and 8 feet long?

Your answer should always contain an abbreviation of the type of measure you are using. For instance, in the problem above, 6 feet by 8 feet, the answer is 48 but now we must also include the abbreviation sq. ft which means square feet. Your answer should be 48 sq. ft.

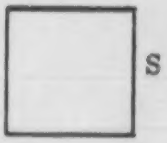
Below are some of the formulas that you can be used to work problems to find square footage.

To find the area of a rectangle, multiply the length by the width.



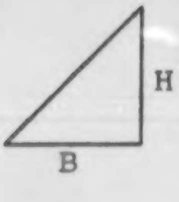
A = LW

To find the area of a square, multiply one side by another side.



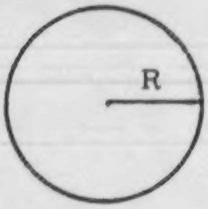
A = S2

To find the area of a triangle, take 1/2 of the base times the height.



A = B/2 H

To find the area of a circle, multiply 22/7 times the radius squared.



$A = 22/7\,R^2$

Cubic

To find a cubic measurement is very easy. It is exactly like finding the square area as done in the section above but this time you multiply the length x width by the height. The formula is L x W x H.

A box 2 feet long, 3 feet wide and 4 feet high, would contain 2 x 3 x 4 = 24 cubic feet. How many cubic feet would there be in a room 10 feet wide, 10 feet long and 8 feet high?

Again, your answer should contain an abbreviation of your measurements. If your measurements are in feet, you will use cu. ft., if you are using inches, you will use cu. in. What is the abbreviation if your measurement is in yards?

SUMMARY

As a mason, you will be doing a lot of measuring.

Whole numbers are the easiest numbers to use because they require very little skill in addition, subtraction, multiplication, and division.

Common fractions are representative of a quantity less than a whole. They can be added or subtracted, multiplied or divided by performing certain steps to aid in finding the answer.

Decimal fractions are represented by a decimal point. Math operations using the decimal is easy by following certain rules that govern the placement of the decimal.

Basic measurements include linear measurement, computing area and volume. Each measurement should indicate the type of measure you use, such as feet, inches, or yards.

QUESTIONS

1. What is the smallest whole number?
2. List three numbers that are not whole numbers.
3. When adding fractions, what must you do to the bottom number of each fraction?
4. What do fractions being multiplied or divided have in common?
5. What must be done to decimals when you are adding?
6. What are you doing when you have to count the numbers to the right of the decimal?
7. Measuring off a board 14-feet long is what type measurement?
8. If you measure the floor area of a room, your answer would be written down in what units?
9. What is the formula for finding area?
10. How many cubic feet would be in a house 38-feet long, 24-feet wide with 8-foot ceilings?
11. How are the numbers arranged when subtracting?
12. What operation is performed to determine how many times a quantity is contained in another?
13. What must be done before solving problems with mixed terms?
14. What is an improper fraction?
15. Reduce 18/27 to the smallest possible fraction.
16. How do you divide fractions?

## REFERENCES

1. 2TPT-5111-01, Basic Math-Fractions
2. 2TPT-5111-02, Basic Math-Decimals
3. CDC 55253, Masonry Specialist
4. Chapter 8, Estimating

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## PROJECT PLANNING

### OBJECTIVES

Each student will be able to read and know construction drawing and blueprints; the purposes of plans; and how to interpret construction specifications, symbols, and abbreviations.

### INTRODUCTION

A drawing is a picture, sketch, or diagram. It can be a simple outline of a project to be done, or it can be a very complicated drawing from which blueprints are made.

Planning is a very important part of every Air Force activity. Since all projects with which masonry specialist personnel are concerned involve the expenditure of considerable sums of money, the importance of planning cannot be overemphasized. With normal progression within your career field, there will come a time when you will be a member of a conference where plans are made and specifications are written. From these plans and specifications, blueprints will be made. As a member of a Base Civil Engineer Emergency Force (Prime BEEF) Team, you may be called upon to plan a project that requires repairing or constructing. First write the specifications and then draw the blueprints. Yours would not be expected to be the finished product with which we work in the States, but with a knowledge of planning, type of information included in specifications, and the correct use of symbols and lines on drawings, you could convey to others your ideas and thoughts. Abbreviations used in a drawing are a shortened form of a word or a phrase.

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## ARCHITECTURAL DRAWINGS

Architectural drawings are divided into two general classes: primary drawings, which consist of design sketches and drawings for display purposes; and working drawings (blueprints), which consist of views (flat surface line drawings) giving detailed information necessary for actual construction of the building. The construction of a building is described by a set of drawings which give a thorough graphic description of each part of the operation. Usually, a set of plans begins by showing the boundaries, contours, and outstanding features of the construction site. Succeeding drawings give instructions for erecting the foundation and superstructure; installation of lighting, heating, and plumbing; and details of construction required to complete the building. Although these drawings are prepared in accordance with the general principles of right-angle projections (projections in which the projecting lines are perpendicular to the plane of projection), they differ from other drawings in certain practices. Therefore, as an approach, let's take a brief look at the various types of drawings.

## Working Drawings for Buildings

This section will teach you how to interpret and identify the different types of working drawings that you may encounter on the job. Items to be covered are:

- Plot plans
- Foundation
- Framing plans
- Floor plans
- Elevations
- Sections and details
- Drawing details
- Symbols and terms
- Common abbreviations
- Specifications

The working drawings of a structure are presented in general and detail drawings. General drawings consist of plans and elevations; detail drawings are made up of sectional and detail views. Since it is the purpose of working drawings to be exact about shape and size, working drawings are generally scale-size projects. In some instances, a proportional-size detail drawing may be included to show how parts look when they are assembled.

In architectural drawing, "plan" views are obtained looking down on the object with a vertical line of sight. Plan views correspond to top views and involve only horizontal dimensions of width and depth. Any view involving vertical dimensions is an "elevation." This could be a front view, side view, or any other elevation view, as shown in figure 34. Different elevations are indicated as front, right, etc., or according to the direction from which the view is taken. Note the writing on figure 34 which gives the type and size of materials used in construction. This writing is called construction notes and is usually found at the bottom of the print. The graphic scale is usually located in the lower right corner of prints. In this drawing it is located in the bottom center, and the scale shows that 1/4" in this drawing is equal to 1' - 0".

Because of the size of the object being represented, different scales are used for general and detail drawings. In general, plan views and elevation views are drawn on separate sheets in order to make the view large enough for practical use. Detail views, drawn to a larger scale, furnish information not provided on general views. They are strategically placed on the main views and on additional sheets as needed to give the worker a complete picture of the structure.

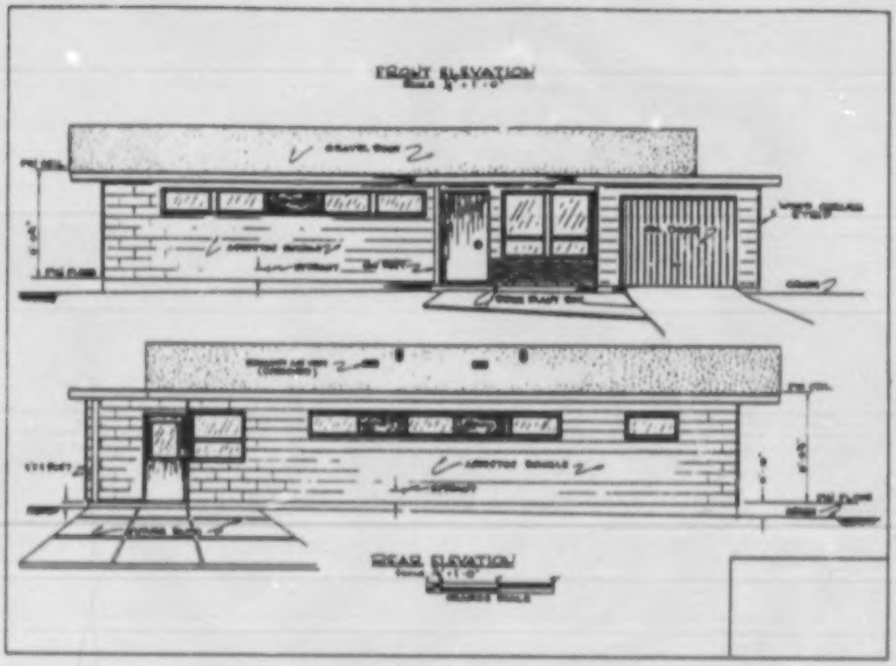

FRONT ELEVATION
REAR ELEVATION

Figure 34. Elevation

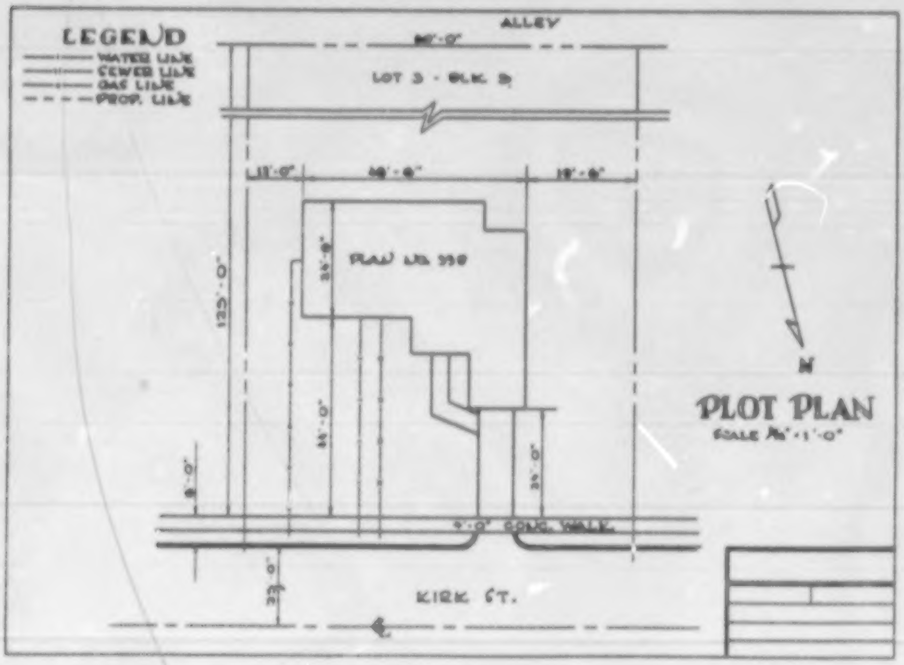

LEGEND
WATER LINE
SEWER LINE
GAS LINE
PROP. LINE
ALLEY
LOT 3 - BLK. 3
PLAN NO. 330
125'-0"
KIRK ST.
4'-0" CONC. WALK
N
PLOT PLAN

Figure 35. Plot Plan

PLOT PLAN. A plot or site plan shows the boundaries of the construction site and the location of the building in relation to the boundaries. It also shows the ground contour, roads, and walks, and locates utility lines, such as sewer, water, gas, etc. These plans are drawn to scale from sketches and notes based on a survey of the area. By locating the corners of the building at specific distances from the established reference points, the plot plan gives the builder a definite starting point. A plot plan is shown in figure 35. The legend in the upper left corner of figure 35shows the symbols for water, sewer, gas, and property lines. The arrow (25' - 0"), located at the bottom of the plan, indicates that the distance from the curb, next to the sidewalk, to the centerline of Kirk St. is 25' - 0". The tile block in the lower right corner of the print tells you what is to be constructed and gives the meaning of different symbols used throughout the plan. The names of the persons responsible for drawing, tracing, checking, and submitting the plan are also in the title block, along with the signature of the engineer responsible for the job and the date. The scale for this plot plan is 5/32" = 1' - 0". (See figure 35.)

FOUNDATION PLAN. The foundation is the starting point in the actual construction, and a completely dimensioned plan is furnished. When a "post and wall" type foundation is used, the foundation plan may be combined with a floor-framing plan. Figure 3 shows a concrete slab foundation which has warm air ducts imbedded in the slab. Detail B of figure 36illustrates a cross-sectional view of the duct, extending from the heating unit, under the concrete floor. The broken lines indicate the ducts and the cross (+) shows the duct opening. Attached to the foundation plan there will be a detail sheet, which consists of the necessary details or specifications needed to complete any given job.

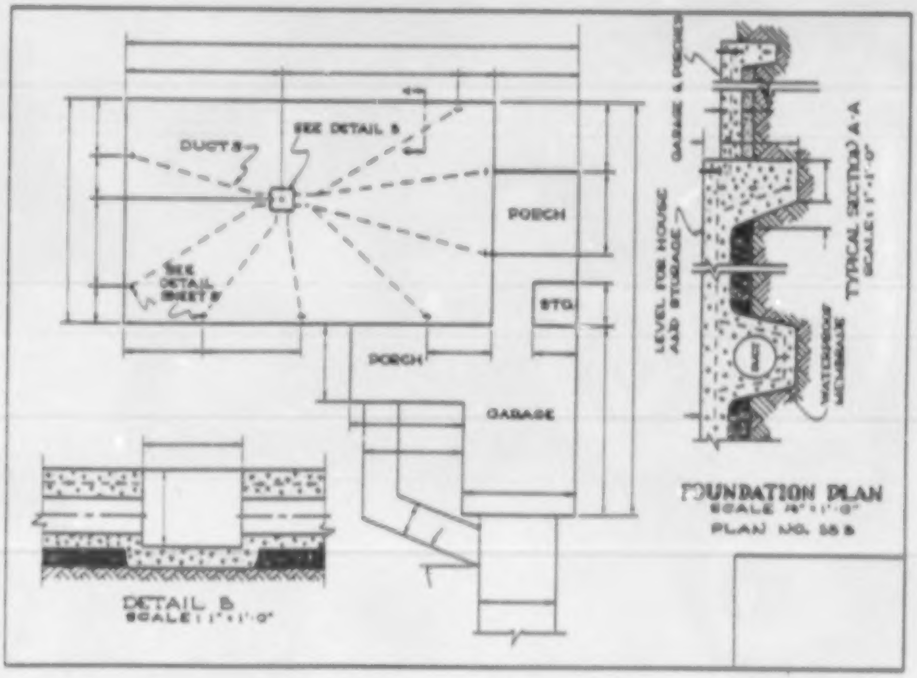

DUCTS
SEE DETAIL B
SEE DETAIL SHEET
PORCH
STG.
PORCH
GARAGE
DETAIL B
SCALE: 1" = 1'-0"
GARAGE & PORCHES
LEVEL FOR HOUSE AND STORAGE
DUCT
WATERPROOF MEMBRANE
TYPICAL SECTION A-A
SCALE: 1" = 1'-0"
FOUNDATION PLAN
SCALE 1/4" = 1'-0"
PLAN NO. 55 B

Figure 36. Foundation Plan

FRAMING PLANS. Framing plans show the size, number, and location of structural members which form the building framework. Separate plans may be furnished for floors, walls, and roofs. The floor-framing plan, shown in figure 37 specifies the size and spacing of joists, girders, and columns used to support the floor. Detailed views are usually added to show the method of anchoring joists and girders to the foundation, as shown in the detail view on the right side of figure 37. Wall-framing plans show the size and location of wall openings, ceiling heights, and other details. Roof-framing plans show the construction of the rafters or trusses which span the building and support the roof.

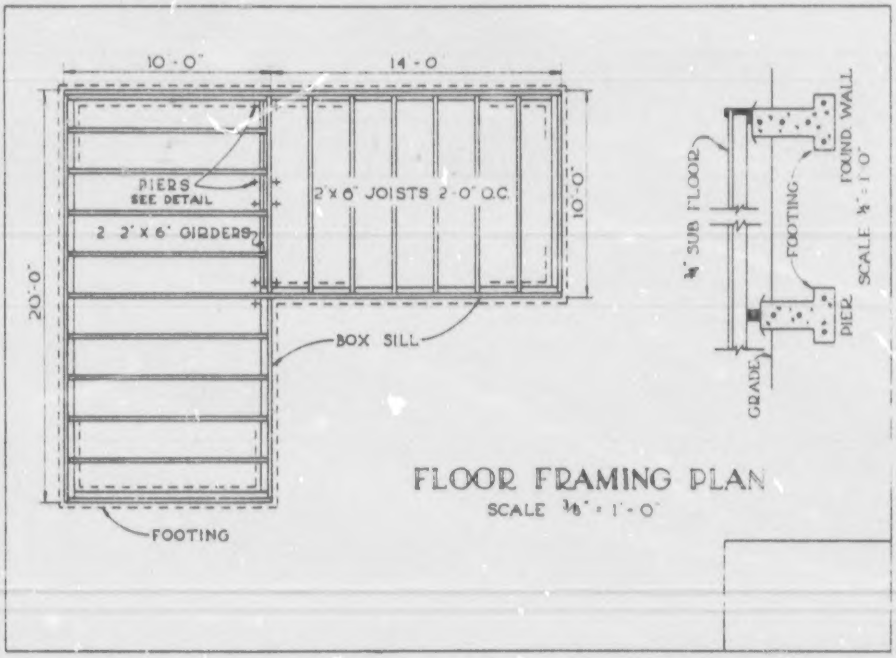


Figure 37. Floor Framing Plan

FLOOR PLAN. A floor plan, shown in figure 38 is a cross-sectional view of the building. This view is obtained by assuming that a building is cut in half horizontally, exposing every room in the building. If the building has more than one floor, a plan for each floor is drawn. The floor plan shows the outside shape of the building: the arrangement and size of rooms; the type of material; and the type, size, and location of doors and windows. In addition, it shows the heating, lighting, and plumbing fixtures.

Floor plans are usually drawn to small scales such as 1/4" = 1' - 0", or 3/16" = 1' - 0". This scale is shown at the bottom of figure 38. For this reason, conventional symbols are used to indicate fixtures and materials. For complex structures it may be necessary to supply separate utilities plans to show electrical, heating, and plumbing layouts. A plumbing plan is shown in figure 39. Some of the plumbing symbols are illustrated under the legend. A symbol for a 40-gallon hot water heater is also shown.

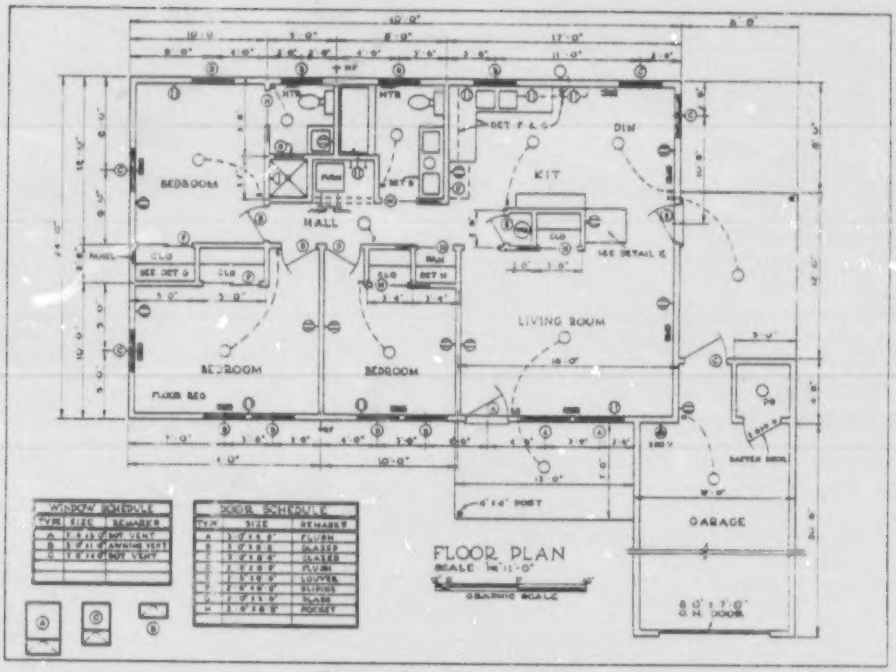

BEDROOM
HALL
KIT
DIN
LIVING ROOM
BEDROOM
BEDROOM
CLO
GARAGE
WINDOW SCHEDULE
DOOR SCHEDULE
FLOOR PLAN
SCALE 1/4"=1'-0"
GRAPHIC SCALE
8'0" x 7'0" O.H. DOOR

Figure 38. Floor Plan

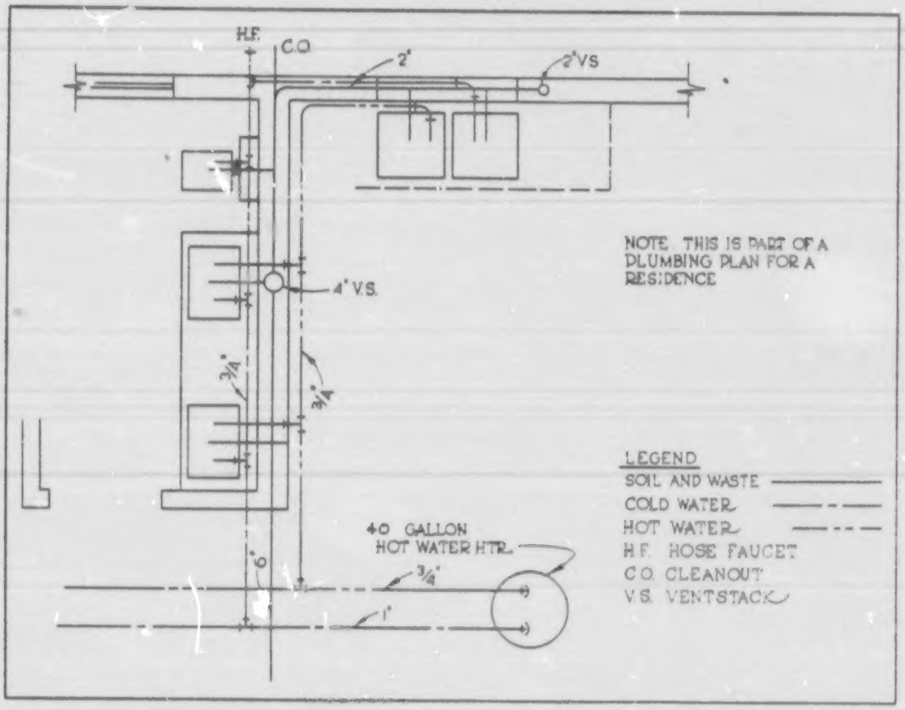

H.F.
C.O.
2"
2"VS
4" V.S.
3/4"
3/4"
6"
40 GALLON HOT WATER HTR.
3/4"
1"
NOTE. THIS IS PART OF A PLUMBING PLAN FOR A RESIDENCE
LEGEND
SOIL AND WASTE
COLD WATER
HOT WATER
H.F. HOSE FAUCET
C.O. CLEANOUT
V.S. VENTSTACK

Figure 39. Plumbing Plan

A floor plan sheet may also contain details of construction, although these are generally presented on a separate sheet. When a detail drawing is furnished to show a particular construction, a reference is noted on the floor plan. Also shown on the floor plan are "schedules" for doors and windows. A schedule is a method of presenting notes and other construction data in the form of a table, as shown in the left lower corner of figure 38. A door schedule specifies the type, size, description, and location of each door, and a window schedule gives the same information for a window. By looking at the letter (B, for example) above the window symbol in figure 38, and then locating the same letter in the window schedule, you come up with the correct size and type of window--in this case 3' - 0" x 1' - 6" awning vent. The correct sizes and types of doors are located in the same manner. Through the use of standard plumbing and electrical symbols, (see figure 39) it is easy to locate plumbing fixtures, hot and cold water-lines, electrical wall and ceiling outlets, switches, types of wire, etc. These symbols are illustrated and explained later in this section. Each person having anything to do with the construction of a building, runway, etc., will have drawings, plans, specifications, and notes pertaining to his particular part of construction. Since all information cannot be presented graphically, construction notes are extensively used. These notes are a vital part of every construction drawing, and they must be carefully worded. There are general notes pertaining to the entire set of plans, and local notes that are important only to certain sheets or certain parts of the drawing.

ELEVATIONS. Elevations are exterior views of a structure and may be taken from the front, rear, right or left side. Being projections on a vertical plane, they show a picturelike view of the structure as it actually is and not as it would appear to the eye. Exterior materials; height of doors, windows, and rooms; and the surrounding ground level can be shown in elevation views. On an elevation view for a single-story building, the floor level is located in reference to the surrounding ground level or "grade," as shown in figure 40. Additional floors above the first floor are located by dimensioning between finished floor surfaces. If the sides of a building are not identical, an elevation for each side must be drawn. If you had access to a plan, you could see that the dimensions given are practically all vertical measurements. However, horizontal dimensions may be placed on an elevation view if it is not possible to show them on a plan view.

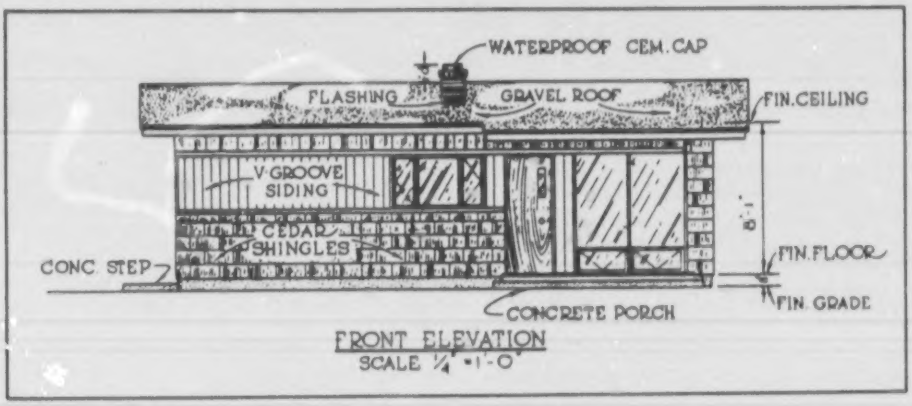


Figure 40. Front Elevation

Since plan and elevation views cannot be drawn as related views on one sheet (except for small structures), scaled measurements must be used for each view. However, a completed plan view may be taped in the proper position on the drawing, and the main dimensions and door and window locations may be projected to an elevation sheet.

Elevation views are made more lifelike by accenting certain lines and adding straight lines to represent the type of material used on the exterior. These representations are shown in figure 40. Lines which may be accented must assume that light is coming from a certain direction and that accented lines represent shaded areas. The use of straight lines to suggest the texture of exterior materials is a form of architectural "rendering." Rendering, as applied to architectural drawing, is the use of pencil, ink, water color, or a combination of these to depict a structure and bring out its form or shape.

SECTIONS AND DETAILS. A section and a detail are practically synonymous; however, no view is called a detail unless it is drawn to an enlarged scale to show construction features more clearly. A south wall detail of living room, a framing detail of gable, and a shelf detail are shown in figure 41. The detail sections show parts of the structure with greater exactness than the small-scale section taken through the structure. When the cutting plan cuts across the narrow part of a structure or building, the view is called a transverse section. A transversal is a line intersecting any system of lines, as indicated in figure 42 (C). Sectional views taken lengthwise are called longitudinal sections. Detail sections which are usually shown are foundation, wall, door, window, or any other section considered necessary to explain the construction.

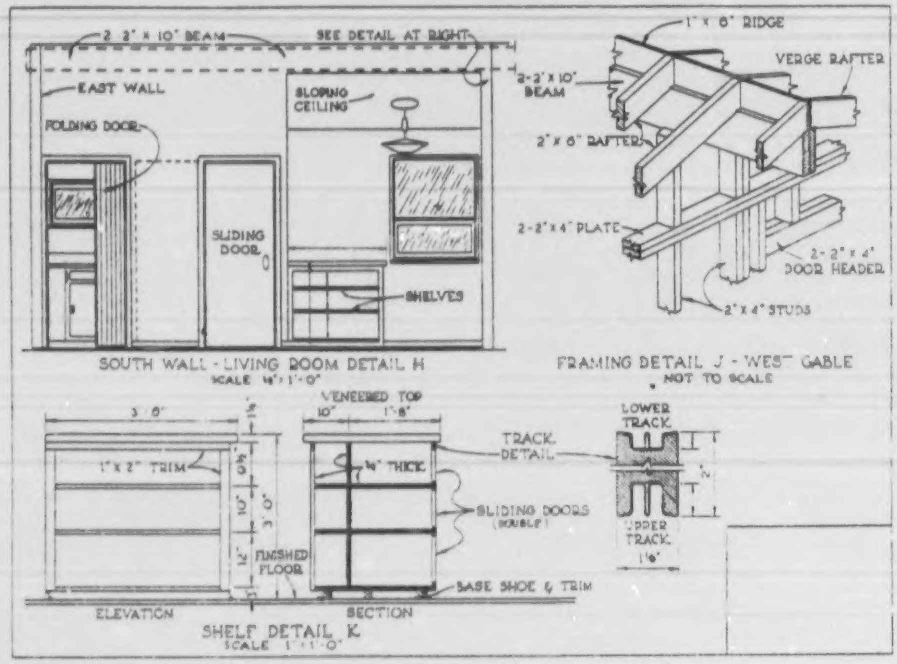

2 2" x 10" BEAM
SEE DETAIL AT RIGHT
EAST WALL
SLOPING CEILING
FOLDING DOOR
SLIDING DOOR
SHELVES
SOUTH WALL - LIVING ROOM DETAIL H
SCALE ¼" = 1'-0"
1" x 6" RIDGE
VERGE RAFTER
2-2" x 10" BEAM
2" x 6" RAFTER
2-2" x 4" PLATE
2-2" x 4" DOOR HEADER
2" x 4" STUDS
FRAMING DETAIL J - WEST GABLE
NOT TO SCALE
3'-6"
1" x 2" TRIM
VENEERED TOP
10"
1'-8"
¾" THICK
10"
12"
3'-0"
FINISHED FLOOR
TRACK DETAIL
SLIDING DOORS (DOUBLE)
BASE SHOE & TRIM
LOWER TRACK
UPPER TRACK
1½"
ELEVATION
SECTION
SHELF DETAIL K
SCALE 1" = 1'-0"

Figure 41. Details

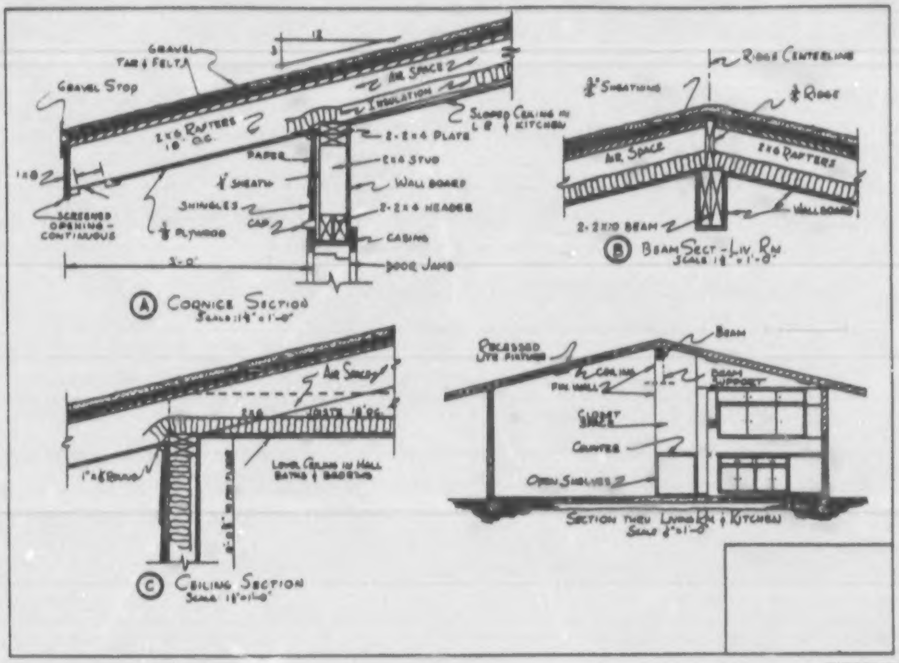

Gravel
Tar & Felt
Gravel Stop
12
3
Air Space
Insulation
Sloped Ceiling in L R & Kitchen
2 x 6 Rafters 18" O.C.
2-2x4 Plate
Paper
2x4 Stud
¼" Sheath
Wall Board
1x8
Shingles
2-2x4 Header
Cap
Casing
Screened Opening - Continuous
⅝ Plywood
3'-0"
Door Jamb
Ⓐ Cornice Section
Scale: 1½" = 1'-0"
Ridge Centerline
¾" Sheathing
¾ Ridge
Air Space
2x6 Rafters
Wallboard
2-2x10 Beam
Ⓑ Beam Sect - Liv. Rm
Scale 1½" = 1'-0"
Air Space
2x6
Joists 18" O.C.
1" x 6 Board
Level Ceiling in Hall Baths & Bedrooms
Ⓒ Ceiling Section
Scale 1½" = 1'-0"
Recessed Lite Fixture
Beam
Ceiling
Fin Wall
Beam Support
Closet Space
Counter
Open Shelves
Section thru Living Rm & Kitchen
Scale ⅛" = 1'-0"

Figure 42. Sections

Exterior detail views, like detail sections are large-scale drawings designed to show features which are too small or too complex to be shown in other views. They are usually developed in right-angle projection but a pictorial projection may be used if it shows the construction to a better advantage. Important parts of detail and sectional views are the notes and dimensions to show the size of materials and the placement of parts in relation to each other. For instance, section A of figure 42 gives such details as rafter sizes (2 x 6 rafters 18" on center), sloped ceiling in the living room and kitchen, gravel roof, etc. The specifications describing the length of the rafters, amount of slope, and the thickness of the gravel roof would be included in the construction notes for the job.

Plan views. It is sometimes difficult to tell the exact shape of a building from the elevation views alone. For this reason, we have a plan view which shows what the structure looks like from a point directly above. This was illustrated on the floor plan and the floor-framing plan. Plan views are very simple and easy to understand, even though they contain a great amount of information.

Detail Views. Elevation and plan views together show the major construction of the building. Both of these views are too small to clearly show minor assemblies; therefore, special drawings are made showing only a portion of the main structure. These are called detail drawings because they show the most minute detail pertaining to the specific portion of the structure, as shown in figure 41. Specifications of materials, dimensions, and other information relative to construction are usually included. These drawings are made to a larger scale in order to give clearer detail. The importance of detail drawings is very easy to understand when you consider the information needed to build kitchen cabinets or stairways.

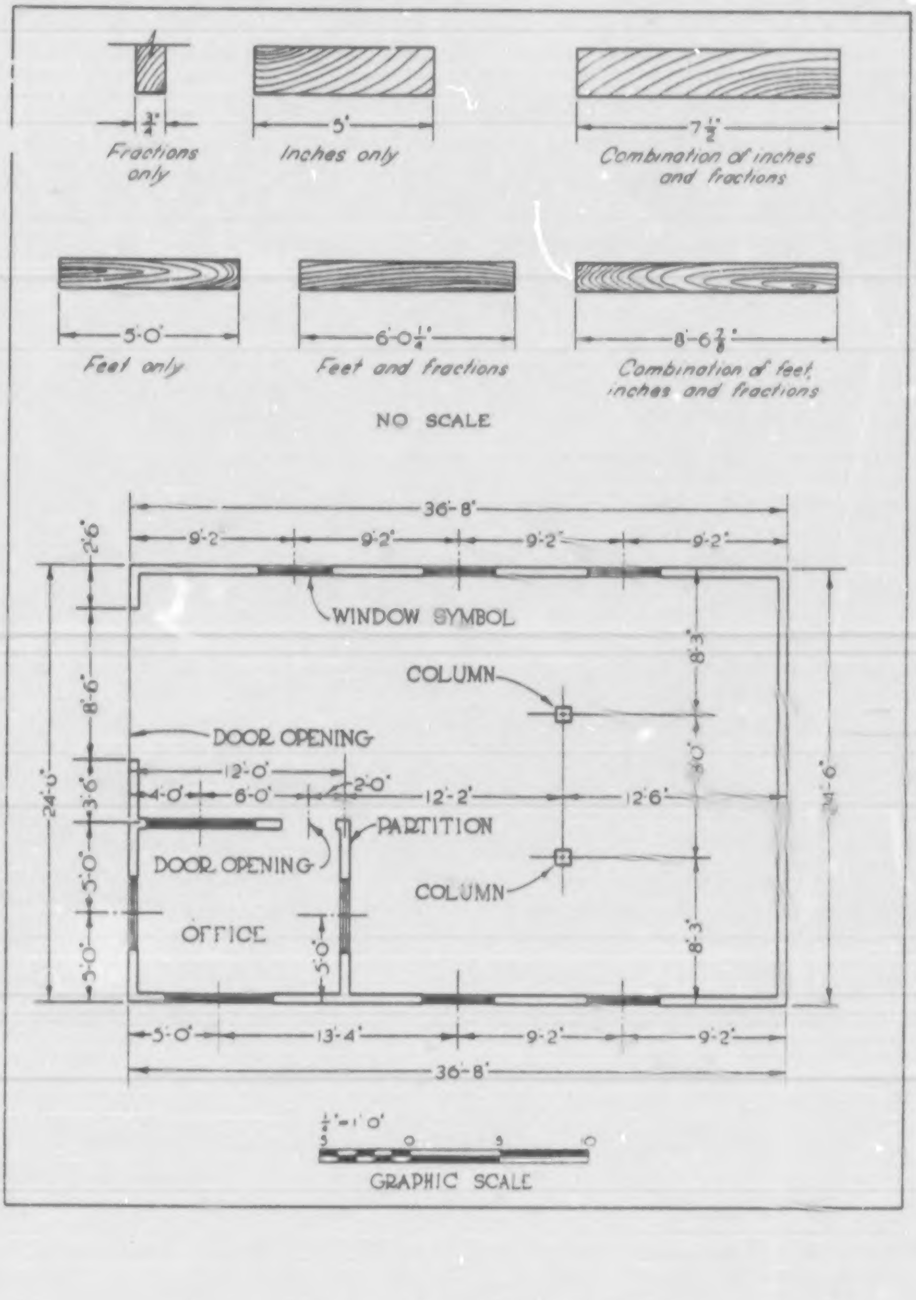

3/4"
Fractions only
5"
Inches only
7 1/2"
Combination of inches and fractions
5'-0"
Feet only
6'-0 1/4"
Feet and fractions
8'-6 3/8"
Combination of feet, inches and fractions
NO SCALE
36'-8"
9'-2"
9'-2"
9'-2"
9'-2"
2'-6"
WINDOW SYMBOL
COLUMN
8'-3"
8'-6"
DOOR OPENING
12'-0"
24'-0"
3'-6"
4'-0"
6'-0"
2'-0"
12'-2"
12'-6"
8'-0"
24'-6"
PARTITION
DOOR OPENING
5'-0"
COLUMN
OFFICE
5'-0"
8'-3"
5'-0"
5'-0"
13'-4"
9'-2"
9'-2"
36'-8"
1/4" = 1'-0"
5
0
5
10
GRAPHIC SCALE

Figure 43. Dimensioning

Sectional Views. To show hidden construction features, various items are often drawn in sections, as shown in figure 42. This is done by cutting the item in the same manner that you would cut a wooden box to show the floor plan. The box is shown first with a line marking the cutting plane. A heavy dotted and dashed line is used to represent the place where the cut is to be made. The line has arrows at right angles to it, representing the direction in which the section is viewed. The section line is usually labeled "A-A," "B-B," and so on through the alphabet if several views are required. The most important value of a sectional view is that dimensions can be shown for parts that are completely hidden.

DRAWING DETAILS. The titles placed on drawings are very important. When they are placed on a drawing, they will be strategically placed to clearly refer to the part, detail, or view which they identify. Titles for rooms will stand out clearly near the center of the area. Titles for detail views will be carefully placed for easy reading and correctly identified according to the reference system being used throughout the set of plane.

Dimensioning. Dimension lines are usually unbroken between extension lines, and dimensions are given in feet and inches. The numerals are placed slightly above or in the dimension line with the reading position from the bottom and right-hand edge of the sheet. The main requirement is that dimensions be clear, definite, and unmistakable. Figure 43 shows how fractions, inches, feet, and combinations of these are specified on plans or drawings.

Components of Drawings. The blueprint method of reproduction has been so widely used that plans of all types are now quite often called blueprints. The blueprint is the builder's guide. It is a complete diagrammatic sketch, with dimensions, of a structure to be built and contains most of the information needed by the builder. All builders must know how to read blueprints and build by them. The blueprint, as used by the builder, is made up of different types of lines showing various views with a scale and legend. Figure 44 shows some of these lines.

Working Lines. The lines which represent the edges of surfaces are somewhat heavier than the other lines on the drawing and are known as working lines. These lines may be straight or curved, depending upon the shape and view of the object.

Centerlines. Centerlines indicate the center of an object. They are also used to show the center of holes or openings in objects and curved portions.

Extension Lines. It is sometimes necessary to lengthen or extend working lines on a drawing. These lengthened lines are known as extension lines. The end of an extension line should never join the working line which it extends.

Dimension Lines. Dimension lines are used to show the size of a structure or any structural part. They are light lines drawn between working lines or extension lines to shown the distance between two points. Each end of the dimension line has an arrowhead to indicate the point where the measurement begins and ends. The points of the arrow should just touch the line where the measurement starts and stops. Numerals which give the exact distance between the arrow points are placed somewhere in the length of the dimension line. When working lines are too near each other to place a dimension line between them, two dimension lines are placed outside the working lines with the arrows pointing toward each other and the numerals placed outside one of the dimension lines.

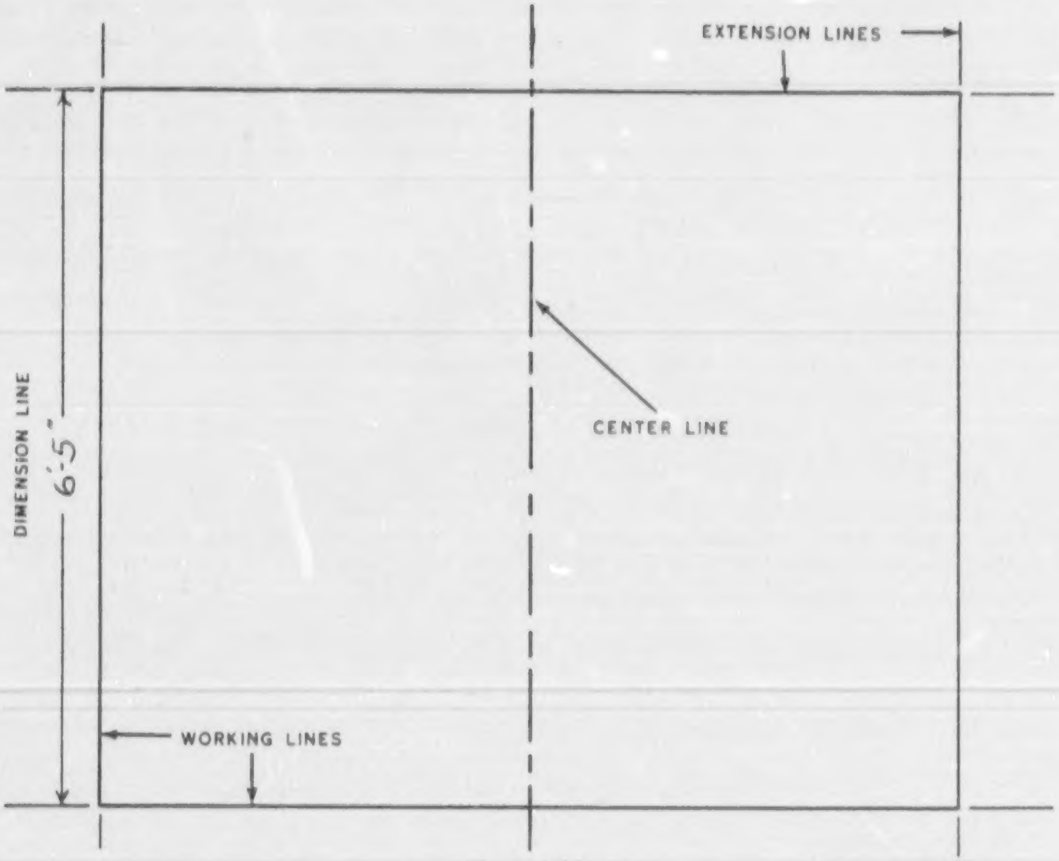
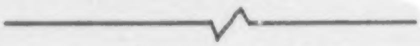


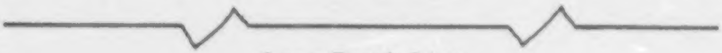
Figure 44.

**Hidden Lines.** An outline of a part which is invisible in the particular view is known as a hidden line and is represented by a series of short dashes approximately 1/8 inch in length. The space between dashes is about equal to the length of the dash. This is an example of a hidden line - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -.

**Break Lines.** Two types of break lines are used. One kind indicates short breaks and the other indicates long breaks. The short break line is drawn freehand. A ruled line with occasional freehand zigzags is used for long breaks. Break lines indicate that an object continues without change in detail. Only a short portion of the entire object is represented when break lines are used.



Short Break Line



Long Break Line

SYMBOLS AND TERMS. Architectural symbols and terms are used to simplify the drawing. In order to read and understand blueprints, you must be able to recognize and interpret these symbols and terms. Some of the more common symbols are shown in figure 45, 46, and 47. See how many of them look like what they represent. Now read through the list of terms and definitions below.

| | |
|---|---|
| Baseboard | A board placed around a room at floor level to form a finish between the floor and walls. |
| Base Shoe | A molding placed around a room at floor level to form a finish between the floor and baseboard. |
| Beam | A horizontal wood, steel, or concrete member used to provide support. |
| Canopy | A projection over windows, doors, or porches to afford protection against weather. |
| Casement | A window in which the sash opens upon hinges. |
| Casing | The wood trim on the vertical sides and top of an opening in a plastered wall. |
| Chamfer | A beveled surface cut upon the corner of a piece of wood. |
| Cornice | The horizontal molding around the top of a building just below the eaves. |
| Deadening Felt | An asphalt impregnated felt used for waterproofing and weatherproofing buildings. |
| Dormer | A vertical window in a small gable rising from a sloping roof |
| Drip Cap | The projection above the exterior of a window or door to allow water to drain. |
| Eaves | The portion of the rafters which project from the lower edge of the roof. |
| Flashing | Strips of sheetmetal or composition roofing material used to waterproof roof intersections and other exposed places on the outside of the house. |
| Footing | The enlarged portion of concrete located in the bottom of foundation walls to spread the load and prevent settling. |
| Glazing | The process of installing glass in window sashes. |
| Header | A short joist supporting tail beams and framed between trimming joists, the piece of stud or finish over an opening, or a lintel. |

| | |
|---|---|
| Jamb | The side pieces of a finished door or window opening. |
| Knee Wall | The sloping portion of an interior wall which joints the vertical wall and ceiling--used where the wall is less than full room height because it meets the slope of the roof. |
| Laths | Narrow strips to support plaster. |
| Lattice | Crossed or interlaced wood, iron, strips, or bars. |
| Mullion | The construction between the openings of two windows. |
| Mutin | The small, wooden dividing strips which separate panes or lights of windows. |
| Purlin | A timber supporting several rafters at one or more points. |
| Ridge | The highest point of a roof. |
| Sash | The framework which holds the glass in a window. |
| Shakes | Hand or machine split sheets of wood used as waterproof siding for exteriors, especially side walls. |
| Sleeper | A timber laid on or near the ground to support a floor joist; also strips of wood, usually 2 x 2 laid over a rough concrete floor, to which the finished wood floor is nailed. |
| Water Table | The finish at the bottom of a building for carrying the water away from the foundation. |

For more terms refer to back of this study guide for the Masonry Glossary of Terms.

ABBREVIATIONS. Because of the lack of space on blueprints, it is common practice to use abbreviations for many items. Some of the more common abbreviated items are listed below:

| | |
|---|---|
| Apt. | Apartment |
| Bm | Beam |
| Bldg | Building |
| B. R. | Bedroom |
| C. A. | Cold air |
| Clg. | Ceiling |
| Clos., Cl., or C | Closet |
| Cem. | Cement |
| Conc. | Concrete |
| Det. | Detail |
| Diam. | Diameter |
| D. R. | Dining Room |
| Dr. | Door |
| D. S. G. | Double strength glass |
| D. H. | Double Hung |

| | | |
|---|---|---|
| Dn. | - | Down |
| Drgs. | - | Drawings |
| Ea | - | Each |
| El. | - | Elevation |
| Ent | - | Entrance |
| Ext. | - | Exterior |
| Fin. | - | Finish |
| Flash. | - | Flashing |
| Fl. | - | Flooring or Flush |
| Fur. | - | Furring |
| Gar. | - | Garage |
| Galv. | - | Galvanized |
| G. I. | - | Galvanized Iron |
| Gl. | - | Glass |
| H. | - | Hall |
| ht. | - | Height |
| H. A. | - | Hot Air |
| Jb. | - | Jamb |
| K. or Kt. | - | Kitchen |
| Lt. | - | Light |
| Linol. | - | Linoleum |
| L. R. | - | Living Room |
| Mldg. | - | Molding |
| Mull | - | Mullion |
| Mor. | - | Mortar |
| O. C. | - | On Center |
| O. S. | - | Outside |
| O. S. Cas | - | Outside Casing |
| R. | - | Riser or Radius |
| Rm. | - | Room |
| Sec. | - | Section |
| Specs. | - | Specifications |
| S. S. G. | - | Single Strength Glass |
| Wd. | - | Wood |
| Yd. | - | Yard |

Each division of the specifications will contain specific information about the materials to be used on the job. The material section of the carpentry division gives all information related to materials and methods of installation as listed below:

- The exact grade, species, size, and moisture content of wood to be used for various parts of the building.
- The spacing of various members, such as studs, rafters, joists, etc.
- The placing of studs, trimmers, or headers around all openings.
- The type of wood to be used for interior finish when this information is not indicated on the drawings.
- The erection of all members plumb, level, square, and true in accord with details.

105-74-30

- The use of fastening devices, such as nails, bolts, screws, toggles, etc.
- All other information necessary to assure that the materials used are of a certain standard and the quality of workmanship is acceptable.

In addition to the other information included in the specifications, a complete description of the building site should be included. A drawing showing how the building is to be placed on the specified plot of ground should be included in the plans.

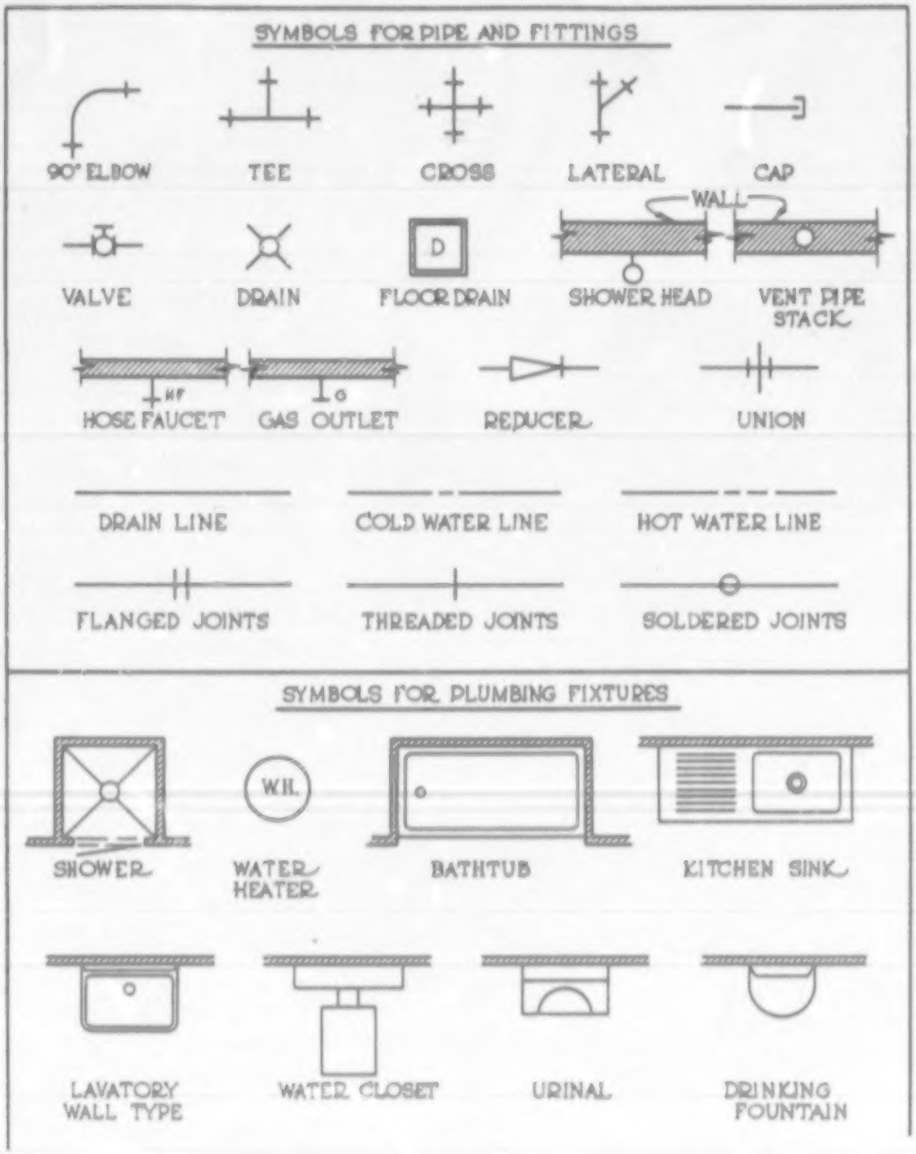

SYMBOLS FOR PIPE AND FITTINGS
90° ELBOW
TEE
CROSS
LATERAL
CAP
WALL
VALVE
DRAIN
D
FLOOR DRAIN
SHOWER HEAD
VENT PIPE STACK
HF
HOSE FAUCET
G
GAS OUTLET
REDUCER
UNION
DRAIN LINE
COLD WATER LINE
HOT WATER LINE
FLANGED JOINTS
THREADED JOINTS
SOLDERED JOINTS
SYMBOLS FOR PLUMBING FIXTURES
SHOWER
W.H.
WATER HEATER
BATHTUB
KITCHEN SINK
LAVATORY WALL TYPE
WATER CLOSET
URINAL
DRINKING FOUNTAIN

Figure 45. Plumbing Symbols

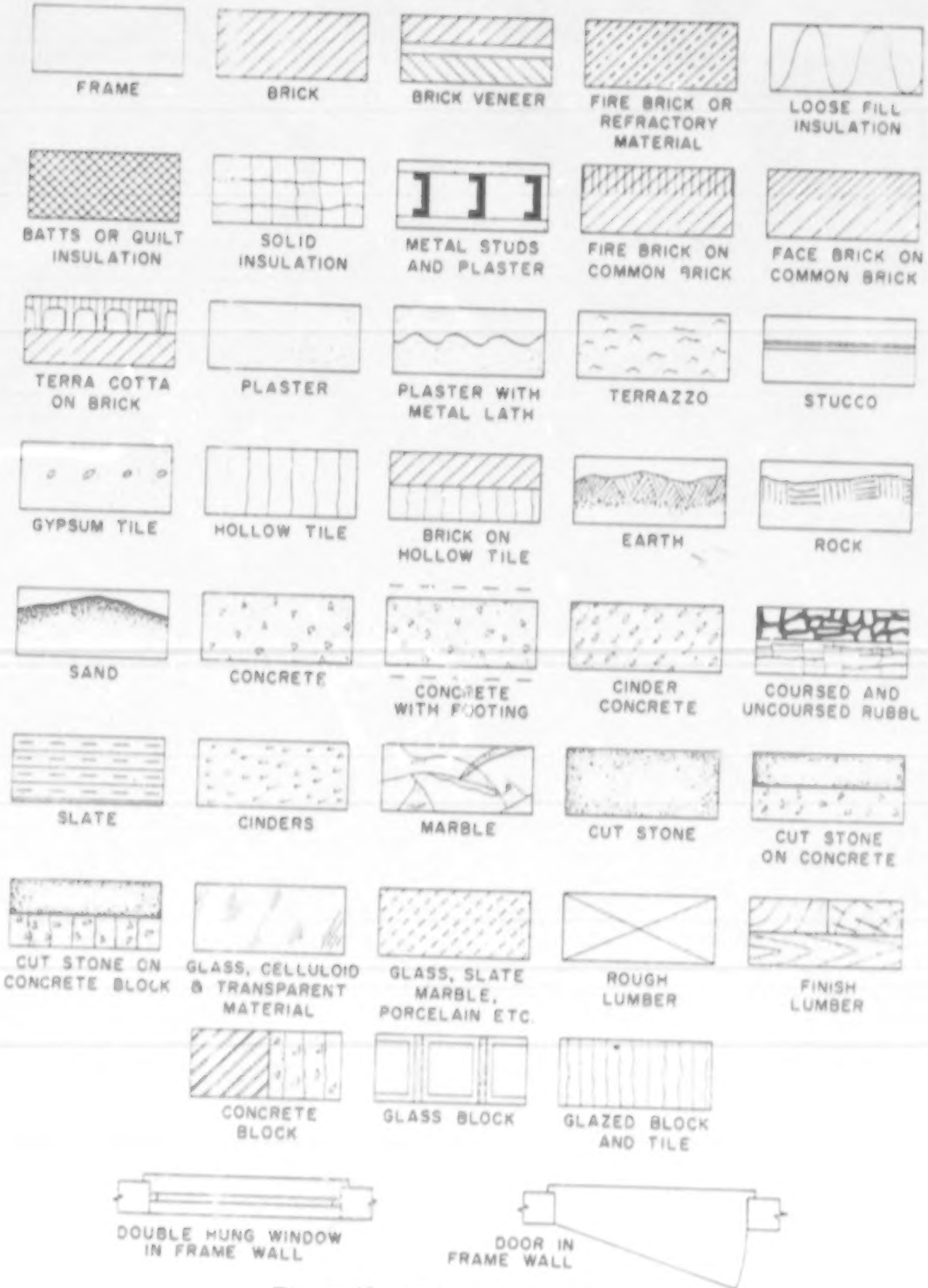

FRAME
BRICK
BRICK VENEER
FIRE BRICK OR REFRACTORY MATERIAL
LOOSE FILL INSULATION
BATTS OR QUILT INSULATION
SOLID INSULATION
METAL STUDS AND PLASTER
FIRE BRICK ON COMMON BRICK
FACE BRICK ON COMMON BRICK
TERRA COTTA ON BRICK
PLASTER
PLASTER WITH METAL LATH
TERRAZZO
STUCCO
GYPSUM TILE
HOLLOW TILE
BRICK ON HOLLOW TILE
EARTH
ROCK
SAND
CONCRETE
CONCRETE WITH FOOTING
CINDER CONCRETE
COURSED AND UNCOURSED RUBBL
SLATE
CINDERS
MARBLE
CUT STONE
CUT STONE ON CONCRETE
CUT STONE ON CONCRETE BLOCK
GLASS, CELLULOID & TRANSPARENT MATERIAL
GLASS, SLATE MARBLE, PORCELAIN ETC.
ROUGH LUMBER
FINISH LUMBER
CONCRETE BLOCK
GLASS BLOCK
GLAZED BLOCK AND TILE
DOUBLE HUNG WINDOW IN FRAME WALL
DOOR IN FRAME WALL

Figure 46. Materials Symbols

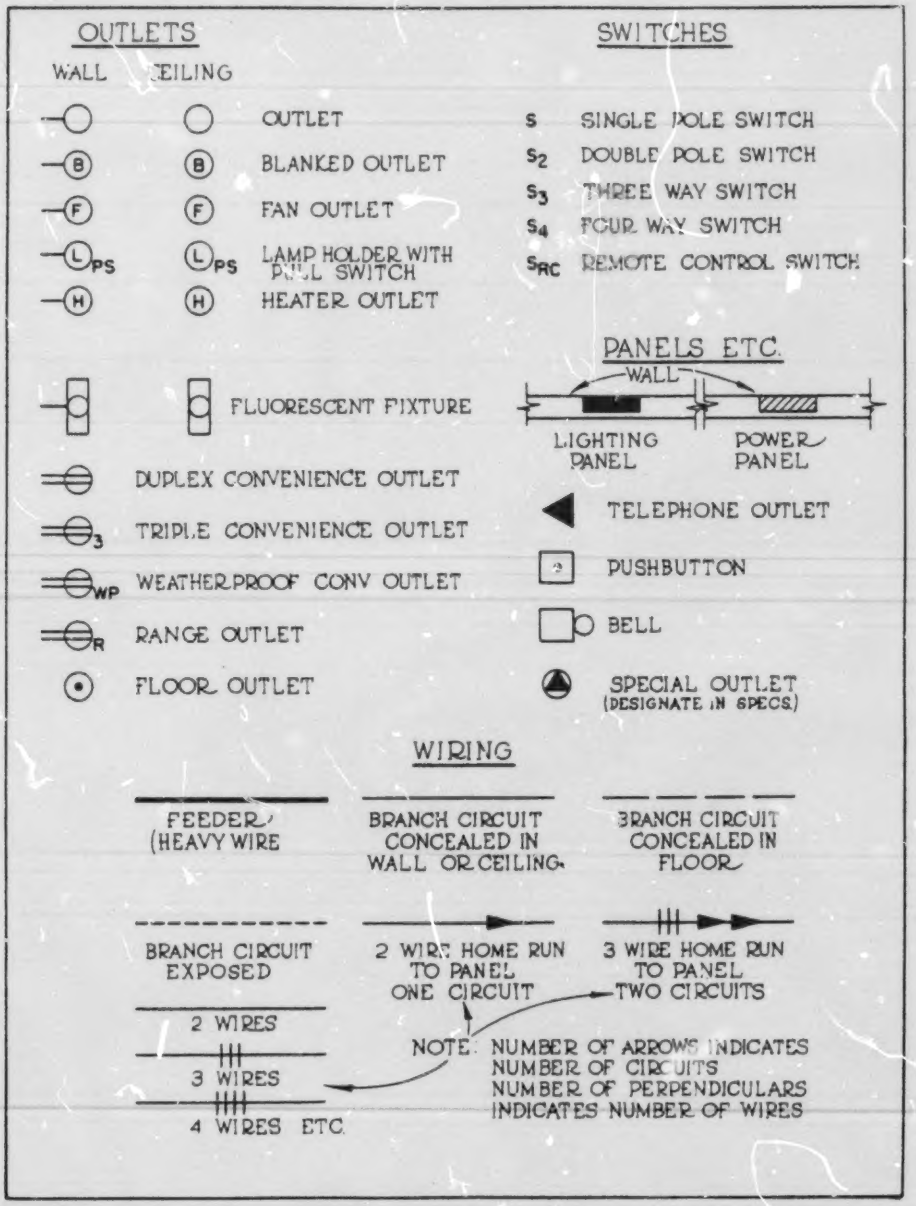

OUTLETS
WALL
CEILING
OUTLET
B
BLANKED OUTLET
F
FAN OUTLET
L PS
LAMP HOLDER WITH PULL SWITCH
H
HEATER OUTLET
FLUORESCENT FIXTURE
DUPLEX CONVENIENCE OUTLET
3
TRIPLE CONVENIENCE OUTLET
WP
WEATHERPROOF CONV OUTLET
R
RANGE OUTLET
FLOOR OUTLET
SWITCHES
S
SINGLE POLE SWITCH
S2
DOUBLE POLE SWITCH
S3
THREE WAY SWITCH
S4
FOUR WAY SWITCH
SRC
REMOTE CONTROL SWITCH
PANELS ETC.
WALL
LIGHTING PANEL
POWER PANEL
TELEPHONE OUTLET
PUSHBUTTON
BELL
SPECIAL OUTLET (DESIGNATE IN SPECS.)
WIRING
FEEDER (HEAVY WIRE
BRANCH CIRCUIT CONCEALED IN WALL OR CEILING.
BRANCH CIRCUIT CONCEALED IN FLOOR
BRANCH CIRCUIT EXPOSED
2 WIRE HOME RUN TO PANEL ONE CIRCUIT
3 WIRE HOME RUN TO PANEL TWO CIRCUITS
2 WIRES
3 WIRES
4 WIRES ETC.
NOTE: NUMBER OF ARROWS INDICATES NUMBER OF CIRCUITS NUMBER OF PERPENDICULARS INDICATES NUMBER OF WIRES

Figure 47. Electric Symbols

## MASONRY GLOSSARY OF TERMS

The following terms are associated with masonry work. Keep this list with you throughout this course.

ABUTMENT - Concrete or masonry supports at end of a bridge or arch.

AGGREGATE, COARSE - Gravel or crushed rock.

AGGREGATE, FINE - Sand.

AGGREGATE GRADATION - The arrangment of sizes.

AIR-ENTRAINING AGENT - A concrete additive that enables concrete to resist freezing and to protect pavements from adverse effects of salts during snow removal.

ALL-ROWLOCK WALL - A wall built with two courses entirely of stretchers on edge, alternating with one course of headers on edge.

AMERICAN BOND - A common bond in very general use as it is quickly laid and is as strong as other bonds. Every fifth or sixth course consists of headers, while the other courses consist of stretchers.

ANCHOR BOLT - Fastens steel or wood members to concrete or masonry.

ANCHORAGE HOOKS - Hooks bent in ends of reinforcing-steel bars for better bond in concrete.

ANCHORS, or TIES - Metal shapes used to secure masonry wall intersections and to fasten other structural members to masonry walls.

ARCH - Any bow-like curve, structure, or object generally spanning an opening, and producing horizontal and vertical reactions.

ARCH, JACK - A construction in which both the underside and outside are flat.

ASHLAR - Dressed stone used for the outside facing of a wall.

BACKING-UP - The using of brick of a cheaper grade for the inner face of a wall.

BASEBOARD - Molding at the bottom of a wall.

BASE COURSE - The first course or foundation course on which the remainder rests.

BASE SCREED - Wooden strips or strips of plaster used for gaging the thickness of plaster coats.

BAT - A broken brick or a part of a brick.

BATTERN (CLEAT) - A strip of wood used for nailing across two other pieces to hold them together, or for covering a crack.

BATTER - The slope of the face of a wall that is out of plumb. The backward and upward slope of a retaining wall.

BATTER BOARD - A temporary framework used to assist in locating the corner when laying a foundation.

BEAM - Horizontal member of a structural frame.

BEATING IN - The process of moving a small board over a tiled surface and tapping it lightly with a hammer to set the tile firmly into the mortar and in one smooth plane.

BED - The horizontal surfaces on which the bricks or stone of the wall lie in courses.

BEDDING - A filling of mortar, putty, or other substance in order to secure a firm bearing.

BED JOINTS - The horizontal mortar joints between courses of brick or, more simply, the bed or mortar on which bricks rest.

BELT - A projecting band course or courses, or a course of a different kind of brick.

BLOCKING COURSE - A course of stones placed on the top of a cornice crowning the walls.

BLOOM - The appearance of a whitish powder on the surface of a brick or stone wall.

BOND - The arrangement or placing of bricks in a wall so as to tie together the face and backing.

BOARD - Lumber less than 2 inches thick.

BOARD FOOT - The equivalent of a board 1-foot square and 1-inch thick.

BOND - Refers to adherence of one material to another as coats of mortar, etc.

BOND COURSE - A course of headers.

BOND STONE - Stone running through the thickness of a wall at right angles to its face, serving to bind it together.

BRACES - Pieces fitted and firmly fastened to two others at any angle in order to strengthen the angle thus treated.

BRICK - A hardened block of clay, usually of rectangular shape, formed in a mold, dried or burned in a kiln.

BRICKBAT - A portion of a brick.

BRICK SET - A tool used to cut brick.

BRICK VENEER - The outside facing of brickwork used to cover a wall constructed of other material. The term generally refers to brick walls inclosing a frame building.

BRIDGING - Pieces fitted in pairs from the bottom of one floor joist to the top of adjacent joists, and crossed to distribute the floor load; sometimes pieces of width equal to the joists and fitted neatly between them.

BROWN COAT - Second coat of plaster used to cover walls and ceilings. Never applied less than 3/8-inch thick.

BUILDING PAPER - Cheap, thick paper, used to insulate a building before the siding or roofing is put on; sometimes placed between double floors.

BULL HEADER - A brick with one rounded corner usually placed with short face exposed. Laid to form the brick sill under and beyond the window frame; also used around doorways.

BULLNOSE CAP - Tile trim used at the top of finished tile surfaces.

BULL STRETCHER - A bull brick laid with the long edge exposed.

BUTTERING - The spreading of mortar on the edges of a brick before placing it in position.

BUTTERING METHOD - The process of applying the neat coat of mortar to the back of each tile.

CALCIUM CHLORIDE - A crystalline compound used in its anhydrous state (as a white porous solid) as a drying agent, to lay dust, etc. Accelerates the hardening of concrete.

CASING - The trimming around a door or window opening, either outside or inside, or the finished lumber around a post or beam, etc.

CEMENT - Product obtained by burning a mixture of limes and clays, and grinding to a fine powder.

CERAMIC - An article made of baked clay. In the tile trade, the word is used to designate a tile made of compressed clay and silica.

CERAMIC MOSAIC TILE - Small pieces of tile, usually mounted on kraft paper, mounted in various patterns. The glazed tiles are used to cover walls and the unglazed tiles are used to cover floors.

CHASING OUT THE BOND - Laying out the first tier or course of masonry units, without mortar, the length of the wall to be constructed.

CLAY - A common earth, compact and brittle when dry, but plastic when wet. Used in the manufacture of bricks.

CLOSER - A portion of a brick used to close the end of a course.

CLOSURE JOINTS - The last two head joints in a course of brick.

COMMON or AMERICAN BOND - The bond in which a header course, either full or Flemish, usually occurs every seventh course, but may appear every fifth or sixth course.

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COMMON BRICK - Brick such as is used for rough work, for filling in or backing.

COMPRESSIVE STRENGTH - The ability of a concrete slab to resist crushing.

CONCRETE - A proportioned mixture of cement, mineral aggregates and water, hardened by hydraulic chemical reaction.

CONCRETE BLEEDING - The flow of cement paste out of a concrete mix.

CONCRACTION JOINT - Sometimes referred to as a dummy contraction joint; is used to control cracks caused by contraction.

CONTROL JOINTS - Joints used to control cracking in plaster surfaces.

COLUMNS - A support square, rectangular, or cylindrical in section, for roofs, ceilings, etc., composed of base, shaft, and capital.

CONSTRUCTION JOINTS - Joints placed at the start and end of a day's pour, or those joints used to separate areas of concrete placed at different times.

COPING - A layer of concrete or a row of brick, generally projecting, used to cap or finish the top of a wall and protect it from the weather.

CORBEL - One or more courses of projecting bricks to form an overhang.

CORNING LEAD - The part of a wall, at the corners or elsewhere, built in advance of the rest of the wall as a guide to which the corner blocks and line are attached.

CORNICE - The molded projection which finishes the top of a wall of a building.

COURSE - To arrange in a row, as a row of bricks laid in a wall.

COVE BASE - Wall tile having a curved upper edge and a curved bottom lip, used as a single wall tile course above the floor tile.

CRAZING - To break into pieces.

CROSS JOINTS - The vertical joints formed when laying a header course of brick.

DASH BOND COAT - Mortar applied to a masonry surface by splattering it with a brush. When the mortar hardens, it leaves a rough surface that makes a good bond between the masonry surface and the scratch coat of plaster.

DEFORMED BAR - Steel reinforcing bars made in irregular shapes to produce better bond between the bars and the concrete.

DIAGONAL BOND - Bricks laid horizontally with ends staggered symmetrically with respect to the diagonal running from corner to corner of the wall.

DRY WALL METHOD - Applying tile adhesive to the back of each tile before setting them. Sometimes referred to as the buttering method.

DUTCH BOND - A bond in which the courses are alternately made up of headers and stretchers.

EMULSIFIED ASPHALTS - A mixture of asphalt cement and water which contains a small amount of an emulsifying agent.

ENGLISH BOND or ENGLISH CROSS BOND - Same as Dutch bond.

EVOLUTION OF HEAT - The heat that leaves the concrete as it hardens.

EXPANSION JOINT - Joints installed primarily to relieve compressive stresses by expansion of concrete. They usually consist of some form of nonextruding filler such as wood, asphalt, etc. which will permit horizontal expansion of the concrete.

EXTRADOS - The outside curve of an arch.

FACE - Front or exposed surface of a wall.

FACEBRICK - Exterior facing of a brick wall.

FILLING IN - The process of building in the center of the wall between the face and brick.

FINISH COAT - Third coat of plaster used to cover walls and ceilings. Never applied less than 1/8-inch thick.

FIRE CLAY - Clay capable of withstanding high temperatures; its quality is due to the large amount of silica and small amount of fluxing agents.

FLAT ARCH (or JACK ARCH) - A construction in which both the soffits and extrados are flat.

FLASHING - The material used and the process of making watertight the roof intersections and other exposed places on the outside of the house.

FLASH SET or PREMATURE SETTING - Rapid hardening of concrete or mortar.

FLEMISH BOND - Consists of alternate headers and stretchers in every course, each header centering on the stretchers in the courses above and below.

FLEMISH BOND, DOUBLE - When both the inner and outer surfaces of an exposed wall are laid in Flemish bond, all headers being true or full headers, the bond is termed "double Flemish bond."

FLEMISH GARDEN BOND - Consists of three stretchers followed by a header in each course. The headers in each course center between the stretchers in the course above and below.

FLEXURAL STRENGTH - The ability of a concrete slab to resist bending.

FLOAT COAT - The second coat of mortar applied to walls that are to be tiled.

FLOATING METHOD - The process of applying the neat coat of mortar to the surface that is to be tiled.

FLOATING TILE - The process of moving a beating block over the tiled surface to get the tiles back in their proper position after they are beat in.

FLUE - The opening in a chimney through which smoke passes.

FLUSH - Adjacent surfaces even, or in some plane (with reference to two structural pieces).

FOOTING - An enlargement at the lower end of a wall, pier, or column, to distribute the load.

FOOTING FORM - Wooden or steel structural, placed around the footing that will hold the concrete to the desired shape and size.

FORM - A temporary mold in which to cast concrete.

FOUNDATION - That part of a building or wall which supports the superstructure.

FRAME - The surrounding or inclosing woodwork of windows, doors, etc and the timber skeleton of a building.

FRAMING - The rough timber structure of a building, including interior and exterior walls, floor, roof, and ceilings.

FRIABLE - Soils that are easily crumbled or pulverized.

FURRING - Narrow strips of board nailed upon the walls and ceilings to form a straight surface upon which to lay the laths or other finish.

GAGE STRIP or ROD - A wooden stick with the height of each course (including bed joints) marked on it. As the wall is being built, the height of each course is checked with the gage strip or rod.

GAGING - To cut bricks or stones to make them uniform in size.

GARDEN BOND - Consists of three stretchers in each course followed by a header, although this bond may have from two to five stretchers between headers.

GLAZE - Melted silica or sand used to coat the tile body, giving it a transparent glassy finish.

GLASED MASONRY UNITS - Masonry units finished with a glasslike coating.

GROUND - A strip of wood assisting the plasterer in making a straight wall and in giving a place to which the finish of the room may be nailed.

GROUT - A fluid cement mixture for filling crevices.

GROUTING - The process of finishing tile joints by filling them with mortar.

GUTTER - A bricked or paved surface in the street adjoining the curb.

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HAUNCH - The shoulder of an arch.

HEADER - A brick or stone placed with one end toward the face of a wall.

HEADER COURSE - A course of brick which have been laid flat with their ends visible.

HEAD FLASHINGS - Bent metal strips placed over openings in brick walls as moisture barriers. When the metal strips are used at the bottom of openings, they are called sill flashings.

HEAD JOINT - The joint between the ends of two bricks in the same course. It is also called a vertical joint.

HERRINGBONE - Masonry or brickwork when laid up in a zigzag pattern.

HERRINGBONE BOND. A zigzag arrangement of bricks or tile, in which the end of one brick is laid at right angles against the side of a second brick.

HONEYCOMBING - An area in the concrete having voids or cavities that are sometimes referred to as rock pockets.

HYDRATION - Reactions between cement and water, resulting in settling and hardening.

IMPERVIOUS TILE - A tile that will resist the absorption of moisture.

JAMB - The side piece or post of an opening; sometimes applied to the door frame.

JOINT - The narrow space existing between adjacent stones, bricks, and other masonry material.

KEEPING THE PERPENDS - The process of keeping vertical joints perpendicular.

KERF - The cut made by a saw.

KEYSTONE. The uppermost stone of a masonry arch, and which locks the other members together.

KING - A brick trimmed for a miter fit at the inside of a corner.

KNEE BRACE - A corner brace, fastened at an angle, stiffening a wood or steel frame to prevent angular movement.

LAMINATED - Formed or arranged in layers.

LAP - The distance one brick extends or projects over another.

LATHS - Narrow strips to support plastering.

LEVEL - A term describing the position of a line or plane when parallel to the surface of still water, an instrument or tool used in testing for horizontal and vertical surfaces, and in determining differences of elevation.

LIMESTONE - A rock consisting chiefly of calcium carbonate, usually an accumulation of organic remains, such as shells, that yield lime when burned.

LINE - The string or cord stretched tightly from lead to lead as a guide for laying the top edge of a brick course.

LINTELS - Usually strips of steel or precast concrete used to support masonry units over openings.

LUMBER - Sawed parts of a log such as boards, planks, scantling and timber.

MASONRY CEMENT - A mixture of portland cement and hydrated lime.

MASONRY UNITS - Units of different shapes and sizes (brick, block, tile, and stone) used with cement mortar to build structures.

MASTIC CEMENT PLASTER - Any of various pasty cements made by boiling tar with lime.

MEMBER - A single piece in structure, complete in itself.

MEMBRANE WATERPROOFING - Layers of roofing felt and hot asphalt used to waterproof surfaces.

METAL LATH - Metal mesh used as a base for the scratch coat of plaster.

MORTAR - A mixture of sand, slacked limes, cement, and water to form a bond between brick, stones, etc.

MORTARBOARD - A board about 3 feet square used to receive mortar ready for use by the mason.

MOUNT SYSTEM - The process of shaping mortar on the back of quarry tiles before setting them.

NEAT COAT - The finish (third) coat of mortar applied to walls that are to be tiled.

NOGGING - The filling-in with brick of the spaces between studding.

NONVITREOUS TILE - A tile that will absorb more than 7 percent of its weight in moisture.

ORGANIC MATTER - Rock or mineral material formed by the activity of plants or animals, or composed of their remains, as coal, chalk, etc.

PARTITION - A permanent interior wall which serves to divide a building into rooms.

PERSPECTIVE DRAWING - A pictorial representation of an object on a plane surface as it actually appears to the eye.

PERPEND - A header brick extending through the wall so that one end appears on each side of it.

PIER - Masonry units built up to support arches, beams, girders, and nonloadbearing walls and partitions.

PILASTER - A right-angled columnar projection from a pier or wall.

PLANKS or LUMBER - Material 2 or 3 inches thick and more than 4 inches wide, such as joists, flooring, etc.

PLAN VIEW - A top view or a view of a horizontal section.

PLASTER - A facing material that is applied to walls and ceilings.

PLASTER METHOD - Referred to setting tile. Applying mortar to the surface being tiled, rather than the tile.

PLASTICIZERS - Materials, such as lime, used to make mortar and concrete more workable.

PLUMB BOB - The pointed weight used to make a plumbline taut.

PLUMB CUT - Any cut made in a vertical plane; the vertical cut at the top end of a rafter.

PLY - A term used to denote a layer or thickness of building or roofing paper as two-ply, three-ply, etc.

POINTING - The finishing of joints in a brick or masonry wall.

POROSITY - State of being porous.

PORTLAND CEMENT - (Not a brand name but a type of cement.) A finely ground material consisting principally of lime with silica, alumina, and iron oxide capable of hardening into a solid mass.

The building cement of common use, made by heating clay and lime substance. The vitrified product, when ground, forms a very strong hydraulic cement.

PRESSED BRICK - Bricks which are pressed in a mold by mechanical power before they are burned.

PROJECTING BELT COURSE - An elaboration of a plain band course of masonry or cutstone work projecting several inches beyond the face of the wall.

PUGGING - A coarse mortar laid between floor joists to prevent passage of sound.

QUARRY-FACED MASONRY - Stone with face left unfinished as quarried.

QUARRY TILE - Generally, a dark reddish tile, very dense, made from natural clays, and used to pave floors.

QUEEN - A half-brick made by cutting a brick lengthwise.

QUEEN CLOSER - A half brick made by cutting the brick lengthwise.

QUOINS - The solid exterior angle or the selected units by which the corner is marked.

RACKING - In approaching a corner where two walls meet, "racking" is the making of each course shorter than the course below it, in order that the workmen on the walls may tie in their courses in the easiest manner.

RACKING BOND - Brick laid in an angular or zigzag fashion.

REINFORCED CONCRETE - Concrete work increased in strength by iron or steel bars imbedded in it.

RETAINING WALL - A wall erected to prevent the sliding of earth or other material.

RETURN - The continuation of masonry units of any kind in a different direction.

RETERMPERED - The act of softening mortar or concrete by remixing and adding water.

RIFFLING - The process of spreading mortar on bricks with the trowel.

RISE - The vertical distance through which anything rises, as the rise of a roof or stair.

ROWLOCK-BACKWALL - Wall made with the bricks of the exterior face laid flat, and the bricks of the backing laid on edge.

ROWLOCK COURSE - A course of brick which have been placed on edge with their ends visible.

RUBBLE - Field or beach stone, or rough stone as it comes from the quarry.

RUBBLE MASONRY - Uncut stone, used for rough work, foundations, backing, etc.

RUSTICATION - Ashlar work with roughened surface and deeply sunk grooves at the joints.

SATURATED SURFACE DRY - Voids in the aggregate are filled with water and the surface is dry.

SCAFFOLD or STAGING - A temporary structure or platform enabling workmen to reach high places.

SCALE - A short measurement used as a proportionate part of a larger dimension. The scale of a drawing is expressed as 1/4 inch = 1 foot.

SCALING - The chipping and breaking of the top protion of concrete surface.

SCRATCH COAT - The first coat of plaster used to cover walls and ceilings. Usually applied between 3/8- and 5/8-inch thick, but in no case less than 1/4-inch thick. Also, the first coat of mortar applied to a surface that is to be tiled.

SCREEDING - The process of striking off the excess concrete to bring a surface to the proper elevation.

SECTION - A drawing showing the kind, arrangement, and proportions of the various parts of a structure. It is assumed that the structure is cut by a plane, and the section is the view gained by looking in one direction.

SECTION VIEW - A drawing representing the internal parts of an object, building, etc., as if it had been cut straight through vertically or horizontally.

SEGMENTAL ARCH - An arch whose curve is an arc of a circle, but less than a semicircle.

SEMICIRCULAR ARCH - An arch whose intrados is a semicircle.

SEMIVITREOUS TILE - A tile that will absorb more than 3 percent, but less than 7 percent, of its weight in moisture.

SHALE - A rock capable of being split and formed by the consolidation of clay, mud, or silt.

SILT - Loose sedimentary material (rock particles less than 1/16 millimeter in diameter) suspended in water. Also, a deposit of this sediment.

SILLS - The horizontal timbers of a house which either rest upon the masonry foundations or, in the absence of such, form the foundations.

SKEWBACK - The surface of each end of an arch upon which the first bricks are laid, and from which an arch springs.

SKINTLED BRICKWORK - An irregular arrangement of bricks with respect to the normal face of the wall, the bricks being set in and out to produce an uneven effect; also the rough effect caused by mortar squeezed out of the joints.

SLAB - Concrete floor or span.

SOFFIT - The underside of an arch, cornice, or staircase.

SOLDIER COURSE - A course in which the bricks stand on end with their edges visible.

SODIUM HYDROXIDE - A white, brittle solid used in making soap, rayon, and paper. Also, used for bleaching.

SPAN - The distance between the bearings of points.

SPANDREL - The irregular triangular space between an arch and the beam above the same, or the space between the shoulders of two adjoining arches.

SPECIFICATIONS - The written or printed directions regarding the details of a building or other construction.

SPLICE - Joining of two similar members in a straight line.

SPRINGER - The stone from which an arch springs.

SQUARE - A tool used by mechanics to obtain accuracy; a term applied to a surface including 100 square feet.

STORY POLE - A piece of wood with marks on it to indicate where the head or cross joints are located, as well as the marked locations and widths of openings in the wall.

STRAIGHTEDGE - A board or tool having a true and straight edge used for leveling and plumbing purposes.

STRETCHER - Brick or stone lying lengthwise in a course.

STRETCHER COURSE - A course of brick which have been laid flat with their edges or faces visible.

STUCCO - Plaster or cement used for external surfacing of wall.

STUD - An upright beam in the framework of a building.

T-BEAM - Reinforced T-shaped concrete beam and floor slab poured as a unit without joints.

TENSILE STRENGTH - The greatest longitudinal stress a substance can bear without tearing apart.

THRESHOLD - The beveled piece over which the door swings; sometimes called a carpet strip.

TIER - One row of brick in a wall.

TILE - The designation for all glazed and unglazed tiles made exclusively from clay, with or without other ceramic materials, and burned in the process of manufacture.

TILE ADHESIVE - A plastic-type material used for setting tiles.

TILE TRIM - Refer to various kinds of tile moldings used to give a finished appearance to floors, walls, and other types of work.

TOOLING JOINTS - The process of compacting mortar in the joints between masonry units that leaves structures having a uniform appearance.

TOOTHING - Leaving a section of brickwork toothed so that the brickwork to follow can be bonded into it. It consists of allowing alternate courses to project a sufficient distance to assure a good bond with the portion to be built later.

TWIG - A tool installed with bricks laid in the middle of a wall between corner leads to hold the line and overcome sag.

VITREOUS TILE - A tile that will absorb less than 3 percent of its weight in moisture.

VITRIFIED TILE - A tile that will absorb less than 3 percent of its weight in moisture.

VITIRIFIED BRICK - A very hard paving brick burned to the point of vitrification and toughened by annealing.

VOUSSOIR - One of the wedge-shaped blocks of stone of which an arch is composed.

WAINSCOTING - Matched boarding or panel work covering the lower portion of a wall.

WALE - A horizontal beam on form construction.

WOODEN BRICK - Piece of seasoned wood, made the size of a brick, and laid where it is necessary to provide a nailing space in masonry walls.

WOOD LATHS - Strips of wood with rough surfaces, approximately 1 1/2 inches in width, used as a base for the scratch coat of plaster.

WORKABILITY - The consistency of a mix that determines the ease with which a mixture can be placed and worked.

## SUMMARY

Success in the Masonry Specialist career field is determined, to a certain extent, by your ability to make and carry out plans. Good planning incorporates the knowledge and experience of others. From planning comes the specifications and blueprints with which you work. To successfully complete any project to which you are assigned, it is essential that you interpret specifications and read the lines, symbols, and abbreviations used on blueprints.

## QUESTIONS

What is the purpose of blueprints?

When would an invisible line be used on a blueprint?

When are specifications for a project written?

Why are symbols used on blueprints instead of words?

What type of information is given on blueprints?

What type of information is found on the first page of the specification?

## REFERENCES

AFM 85-1, Resources and Workforce Management

CDC 55253, Masonry Specialist

# MODIFICATIONS

Pages 85 - 108 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

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## MAINTENANCE OF TOOLS AND EQUIPMENT

### OBJECTIVE

To help you learn to identify, use and maintain tools and equipment necessary for the performance of masonry construction.

### INTRODUCTION

Tools and equipment are a specialist's best friend, for without them he would be helpless. Regardless of whether you are assigned stateside or overseas, you must have available and be able to choose the proper tools and equipment to do your job. You must also have the knowledge and skill to use them properly. Without this knowledge your time is wasted, the efficiency of civil engineering is reduced, and you may cause injury to yourself or to others and damage to expensive equipment.

To make this study guide easier to understand, it is divided into two sections.

- TOOLS
- EQUIPMENT

This study guide does not cover all of the information available on this subject; therefore, it is recommended that you read some of the references listed at the end of this study guide.

### TOOLS

Few words have as many meanings as the word "tools." Each workman has certain tools which he uses in his work. These tools cover a range from such common things as screwdrivers and hammers to such uncommon things as "sky hooks" and "catheads." In this text, only those tools you will be using in your career field will be discussed, since these will be the most important to you.

Volumes have been written on the proper use of handtools but the feeling still persists that they are so simple that no one need bother to point out the right and the wrong ways of using them. This study guide outlines the care, handling and use of basic handtools for your guidance and information. The following suggestions should help you in your career as a Masonry Specialist.

A mechanic uses the tools in his toolkit almost every day. One of the marks of a good mechanic is the care he gives his tools. He prolongs their life and increases his efficiency and the quality of his work by keeping his toolbox organized.

The checklist of a good mechanic looks like this:

1. Keep tools as clean as possible when using them and be sure to clean them before putting them away.

2. Use each tool only for the purpose intended.

3. Have a special place in the toolbox for each tool.

4. Keep every tool in excellent condition. Check tools regularly and replace all broken tools promptly.

5. Make an inventory of tools after each job to prevent leaving tools on the job.

6. Keep junk and unnecessary tools out of the toolbox.

7. Keep toolboxes securely locked and in a safe place when not in use.

Open End Wrenches

Solid nonadjustable wrenches with openings in each end are called open end wrenches.

The size of the openings between the jaws determines the size of the wrench (see figure 55). This means the distance across the flats and not the bolt diameter.

As you look at the open end wrenches notice that the head and openings are at a 15-degree angle to the shank. This offset makes it easier to work in close quarters.

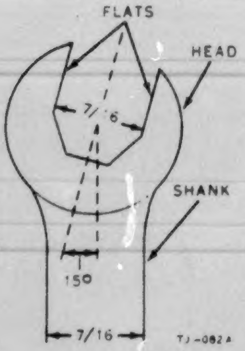


Figure 55. 7/16" Open End Wrench

An elementary trick is that of "flopping" the wrench after every stroke--turning it so the other face is down and the angle of the head is reversed to fit the next two flats of the hex nut, figure 56. This makes it much easier to loosen or tighten a nut. Be sure the wrench fits the nut. A wrench that is too large will round off nut. Always pull on the wrench; never push it.

ADJUSTABLE JAW. The adjustable jaw wrench is similar to the open end wrench, except that one jaw is movable enabling a single wrench to be used on several sizes of nuts or bolts (see fig. 57). The size of the wrench is determined by the length of the handle. Always remember to close the jaws tightly against the nut or bolt before starting work. If this is not done, the nut or bolt will be damaged by the jaws.

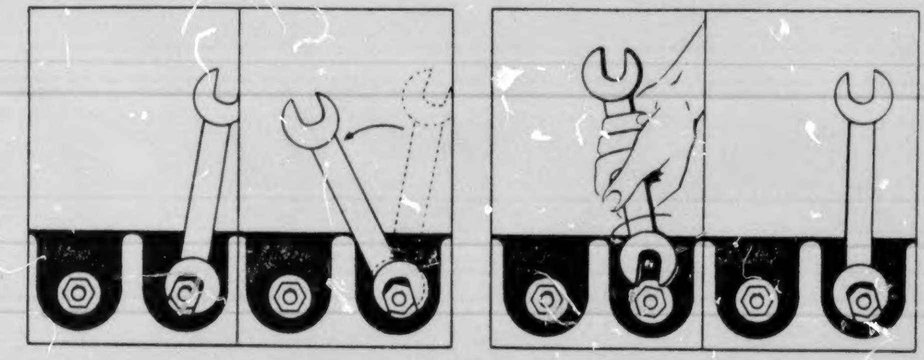


Figure 56. Use of Open End Wrench

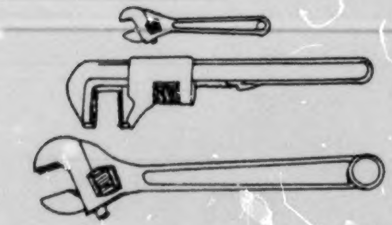


Figure 57. Adjustable Jaw Wrenches

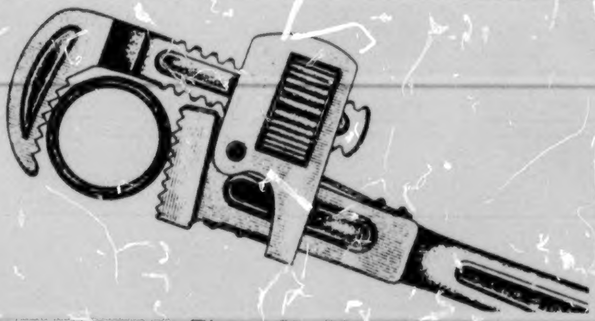


Figure 58. Pipe Wrench

Pipe Wrenches

Pipe wrenches are used for turning pipe, round rods, or smooth fittings which do not offer a gripping surface for other types of wrenches (see figure 58).

Allen Wrenches

Allen wrenches are merely six-sided bars bent into the shape of an "L." They are used to turn internal wrenching bolts and screws (see figure 59).

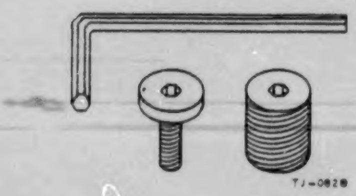


Figure 59. Allen Wrench Application

In deciding which is the best wrench to use, study the job to be done and consider the working space. Space and convenience greatly dictate the type of wrench you will use. Box end or socket wrenches are generally considered first choice wrenches because they are less apt to slip.

Cleaning and Care of Wrenches

Wash grease and dirt from wrenches with cleaning solvent. Wipe dry with a clean dry cloth. Scour rust from wrenches with crocus cloth or aluminum oxide abrasive cloth. Apply a thin coat of oil to handtools which show a tendency to rust.

## Hammers

The ball-peen hammer (see figure 60)is often used by the mechanic to shape soft metal with the peen end and hammer harder metals with the face (figure 61). It is also used for driving chisels.

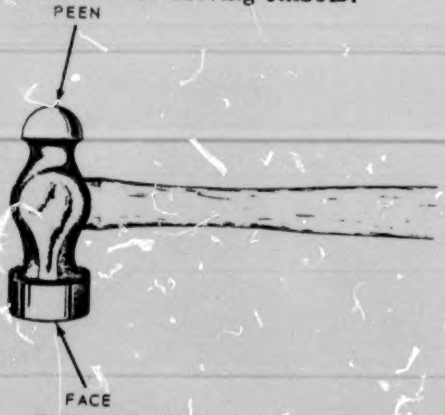


Figure 60. Ball-Peen Hammer

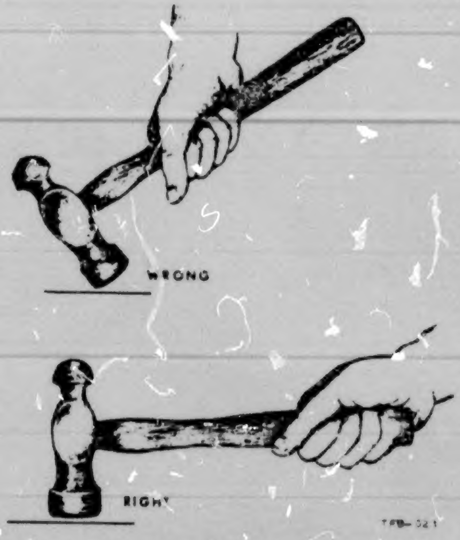


Figure 61. Use of Hammer

## Brick Hammer

A brick hammer is used for both pounding and cutting. It has both a cutting blade and a square peen for pounding or breaking and splitting brick or block. A brick hammer is shown in figure 62.

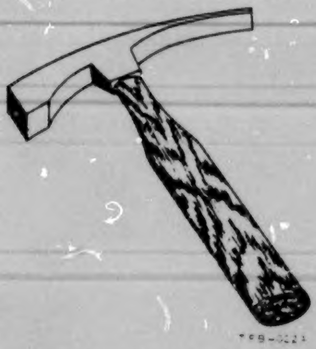


Figure 62. Brick Hammer

## Tile Hammer

A tile hammer looks like a brick hammer, but it is much lighter in weight. It weighs only $3\frac{1}{2}$ ounces. It has both a cutting blade and a square peen for breaking or cutting ceramic tile. It is also used for cutting holes in tile. Figure 63 shows a tile hammer.

## Claw Hammer

The claw hammer is used for driving nails and tacks. The claws on the hammer are for removing nails or tacks. Figure 64 shows a claw hammer.

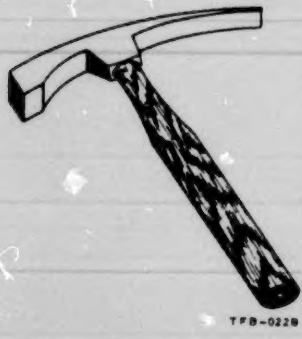


Figure 63. Tile Hammer

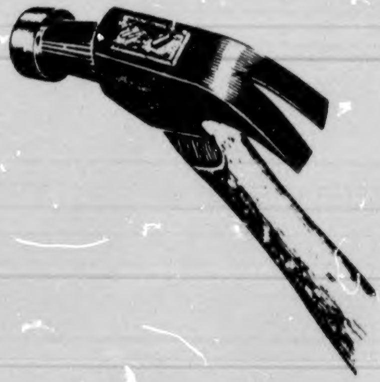


Figure 64. Claw Hammer

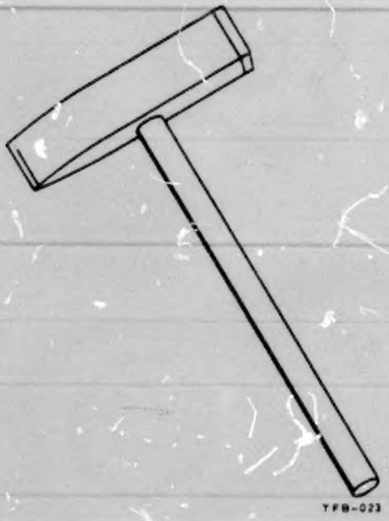


Figure 65. Stone Hammer

### Stone Hammer

The stone hammer is used in stonework for splitting, breaking, squaring, and shaping all types of stone used in the masonry field. Figure 65 shows a stone hammer.

### Common Screwdriver

The common screwdriver has a flat blade, the faces of the blade being almost parallel at the point.

Screwdrivers are usually identified by size according to the combined length of the shank and blade (see figure 66). Measure the screwdriver from the base of the handle to the tip of the blade. This gives the screwdriver size. Common sizes are 3", 4", 5", 6", 8", 10", and 12".

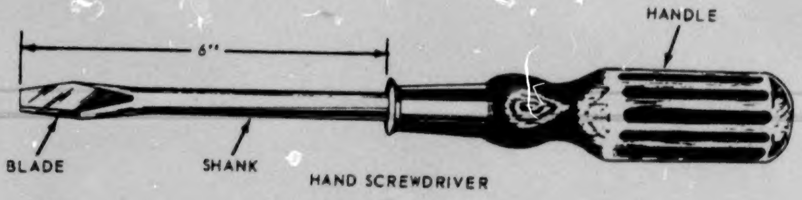


Figure 66. Six-Inch Screwdriver

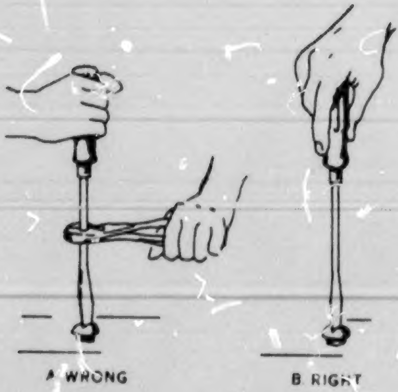


Figure 67. Exert Pressure Downward

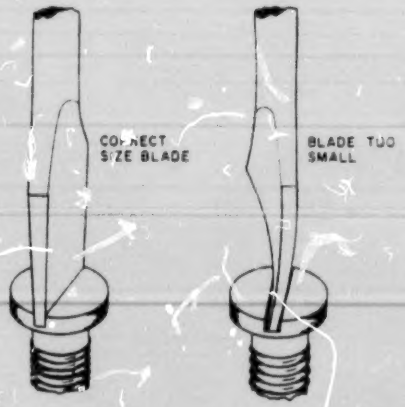


Figure 68. Blade Size

When using a screwdriver, pressure should be exerted straight down on the handle as shown in figure 67. When selecting a screwdriver for use, select the largest blade that will fit the screw slot.

Too much emphasis cannot be placed on selecting a screwdriver that fits the screw slot. Figure 68 will aid you in selecting the correct size screwdriver. A screwdriver of the correct size for the screw slot will prevent marking of the blade tip, prevent breaking or bending the tip of the blade, reduce the force required to keep the screwdrivers in the slot, and prevent damage to screw slot. Remember, there is a properly sized screwdriver for every job.

There are other types of screwdrivers with which you may need to adjust your equipment. These screwdrivers are cross point, offset, and clutch. Figure 69 shows these types of screwdrivers.

### Cross Point Screwdriver

The cross point screwdriver has a blade that forms a cross. There are two kinds of cross point screwdrivers, the Phillips, and the Reed and Prince. The Phillips has a blade that tapers to a blunt point. The Reed and Prince has a blade that tapers to a sharp point.

Figure 70 shows the two types of cross point screwdrivers.

### Offset Screwdrivers

Blades of offset screwdrivers are set 90° from the shank and handle. The blades are at angles to one another so that, by alternating the use of the blades, a screw can be tightened or loosened with very little movement. Figure 69 shows offset screwdrivers.

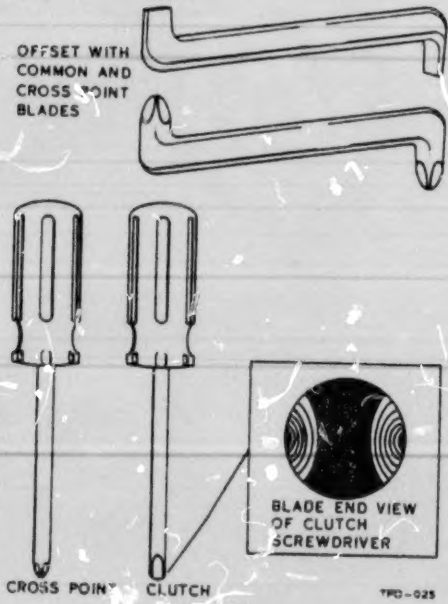

OFFSET WITH COMMON AND CROSS POINT BLADES
BLADE END VIEW OF CLUTCH SCREWDRIVER
CROSS POINT
CLUTCH
TFD-025

Figure 69. Types of Screwdrivers

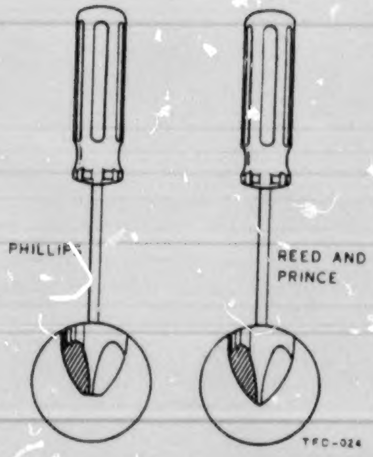

PHILLIPS
REED AND PRINCE
TFD-024

Figure 70. Cross Point Screwdrivers

Saws

There are two types of saws with which you will work. One type is the handsaws, the other type is the hacksaw.

Handsaw

Handsaws are used to cut wood for making forms and for cutting plywood for backing for tile.

There are two types of handsaws, the ripsaw and the crosscut saw. The ripsaw is used for cutting with the grain of the wood. The crosscut saw is used for cutting across the grain of the wood. Figure 71 shows the difference between the two saws.

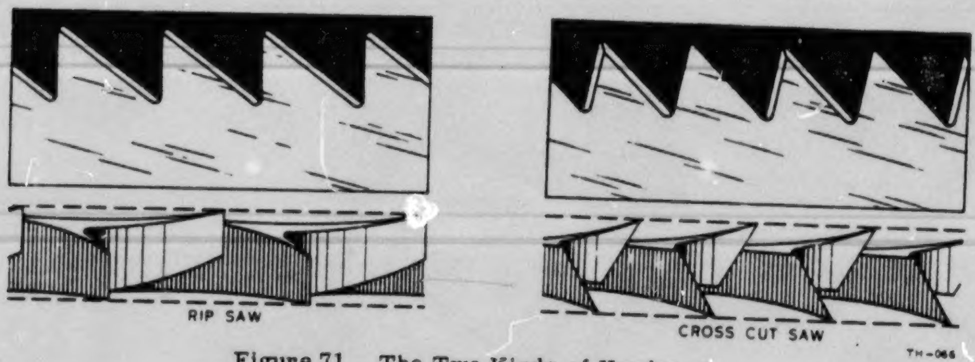

RIP SAW
CROSS CUT SAW
TH-066

Figure 71. The Two Kinds of Handsaws

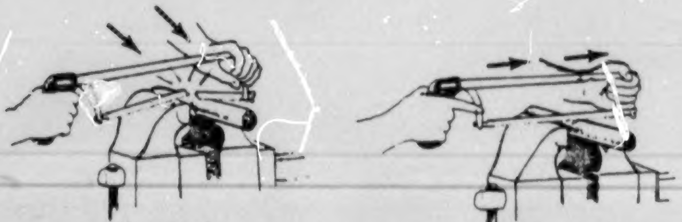
### Types of Hacksaws

Hacksaws are made in different shapes and sizes, depending upon the purpose for which they are to be used. Hacksaws may have a rigid frame in which only a blade of one certain length will fit. Others have adjustable frames that will hold blades from eight to sixteen inches long.

HACKSAW BLADES. Hacksaw blades are made of high-grade steel, hardened and tempered. They are placed in the frame and the teeth pointing forward. Hacksaw blades may have 14, 18, 24, or 32 teeth per inch. The number of teeth per inch indicates the pitch of the blade. Low pitch blades have coarse teeth, and high pitch blades have fine teeth.

### Correct Use of Hacksaw

The hacksaw should be held firmly to prevent blade from "chattering" and twisting. It must also be held at such an angle that at least two teeth will be cutting at all times (see figure 72). The cut should be released and the blade drawn straight back. After the first few strokes, the strokes should be as long as the hacksaw frame will permit, and no pressure applied on the backstroke. Speed should be held down to 40 or 50 strokes per minute, and never be more than 60 per minute. Just before the cut is finished pressure should be relieved from the hacksaw and the rapidity of strokes decreased.



A. WRONG
TOO GREAT PRESSURE
BLADE BREAKS

B. RIGHT
CORRECT PRESSURE
BLADE CUTS ON STROKE

TC-085A

Figure 72. Correct Use of Hacksaw

### Files

Files are used for cutting, smoothing and/or removing small amounts of metal.

TYPES OF FILES. Files are made with single-cut or double-cut teeth. Single-cut files have only one set of teeth in paralleled rows. Double-cut files have two sets of teeth cut at an angle to each other, forming diamond-shaped teeth, which cut faster than single-cut files (see Fig. 73).

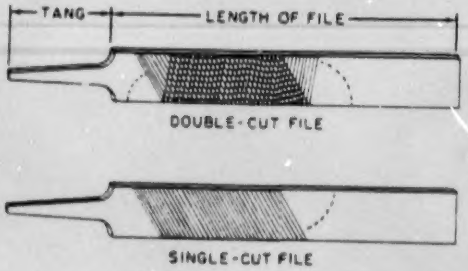


Figure 73. Single-Cut and Double-Cut Files

15B-74-594

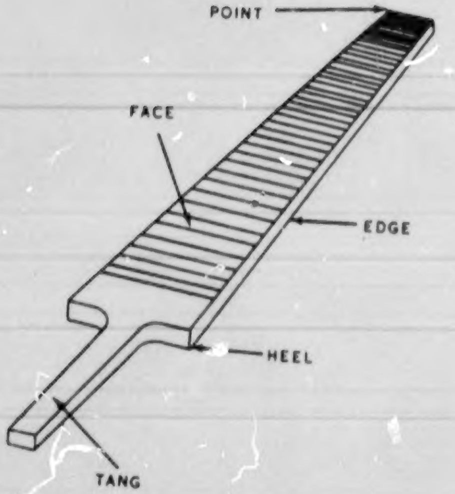


Figure 74. TC-093

## Cutters

In the masonry field you will have to cut certain types of metal and wire. Some of the tools you will use are diagonal-cutting pliers, side-cutting pliers, bolt cutters, and metal shears.

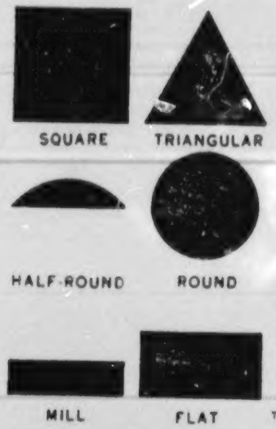
Diagonal-cutting pliers, are used for cutting wire, removing cotter pins, and spreading split ends of cotter pins after the pin has been inserted. When cutting cotter pins, cup your hand or lay a rag over the pins to prevent the loose ends from flying into your face. Figure 77 shows diagonal-cutting pliers.

The next type of cutting tool is the side-cutting pliers. The jaws of side-cutting pliers have gripping surfaces and cutting edges. Figure 77 shows side-cutting pliers.

Cutting teeth on a file are on the face and edge. There are some files that do not have teeth on their edges. See figure 74.

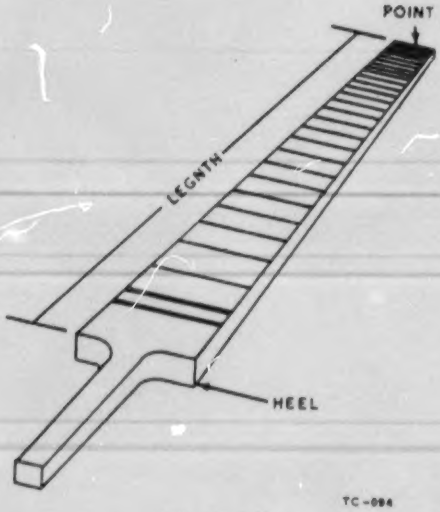
The names of files depend upon their shape, size, and type of cut. Some cross-section views of file shapes are shown in figure 75.

File size is its length from point to heel. See figure 76.



TC-095

Figure 75.



TC-094

Figure 76.

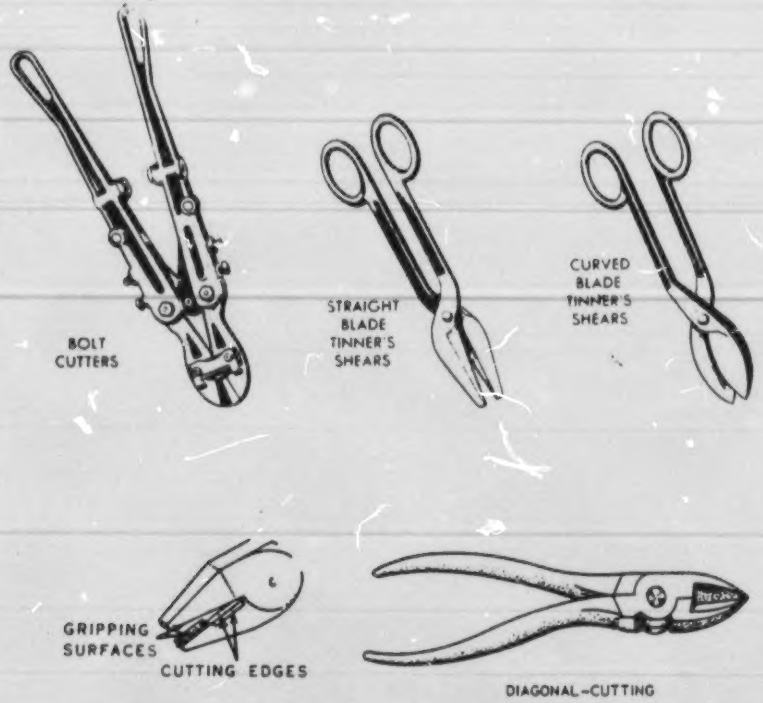

BOLT CUTTERS
STRAIGHT BLADE TINNER'S SHEARS
CURVED BLADE TINNER'S SHEARS
GRIPPING SURFACES
CUTTING EDGES
DIAGONAL-CUTTING

Figure 77. Cutting Tools

Shears

Shears are used for cutting sheet metal of various kinds. Straight blade tinner's shears are used for making straight cuts. Shears with curved blades are convenient for making curved cuts. Bolt cutters are used for cutting bolts and small bars of metal.

Measuring Tapes and Rules

Measuring tools are used by the Masonry Specialist to measure such things as forms and laying out masonry corners.

Tapes and rules are usually graduated in 1/4, 1/8, and 1/16 inch. Some instruments are graduated so that you may even read 1/32 and 1/64 inch (see figure 78). Note the graduations in figure78 have been exaggerated so that you can see them better. The carpenter square has similar markings. You will use the square in making forms.

Cement Trowel

Cement trowels are made of steel and are used to produce a dense hard, smooth finish on concrete. They come in sizes that range from 3", 4", 4½" and 4 3/4" wide. To 10", 10½", 11", 11½" 12", 14", 16", 18", and 20" long. Figure 79 shows a cement trowel.

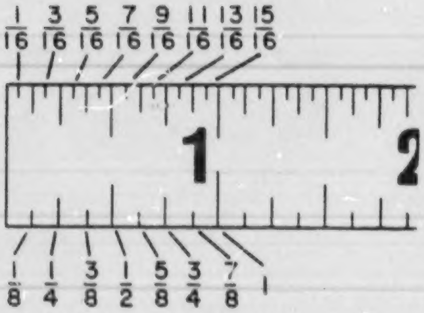

1/16
3/16
5/16
7/16
9/16
11/16
13/16
15/16
1
2
1/8
1/4
3/8
1/2
5/8
3/4
7/8
1

Figure 78. Graduations on Rules and Tape (Not to Scale)

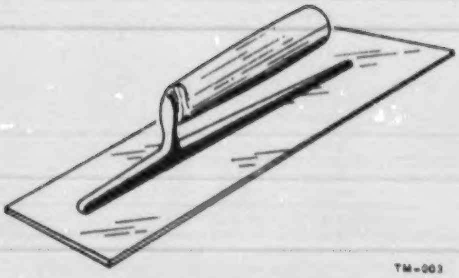


Figure 79. Cement Trowel

Brick Trowel

Brick trowels are used by the mason to spread mortar, to cut block and brick, and to strike joints. Figure 80 shows brick trowels.

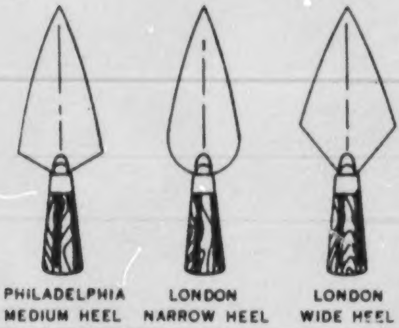

PHILADELPHIA MEDIUM HEEL
LONDON NARROW HEEL
LONDON WIDE HEEL

Figure 80. Brick Trowel

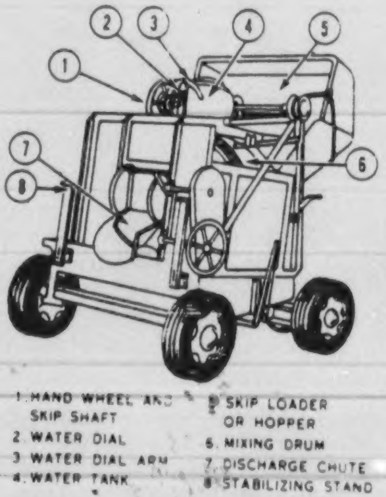

1
2
3
4
5
6
7
8
1. HAND WHEEL AND SKIP SHAFT
2. WATER DIAL
3. WATER DIAL ARM
4. WATER TANK
5. SKIP LOADER OR HOPPER
6. MIXING DRUM
7. DISCHARGE CHUTE
8. STABILIZING STAND

Figure 81. Concrete Mixer

Concrete Mixer

Although most concrete is bought locally and delivered by Transit Mixers, you should know how to operate a concrete mixer. A concrete mixer is best suited for mixing concrete for large jobs. Figure 81 shows a concrete mixer.

Concrete Saw

The concrete saw is used for cutting out concrete for special purposes. It is also used for making joints in concrete. Figure 82 shows a concrete saw.

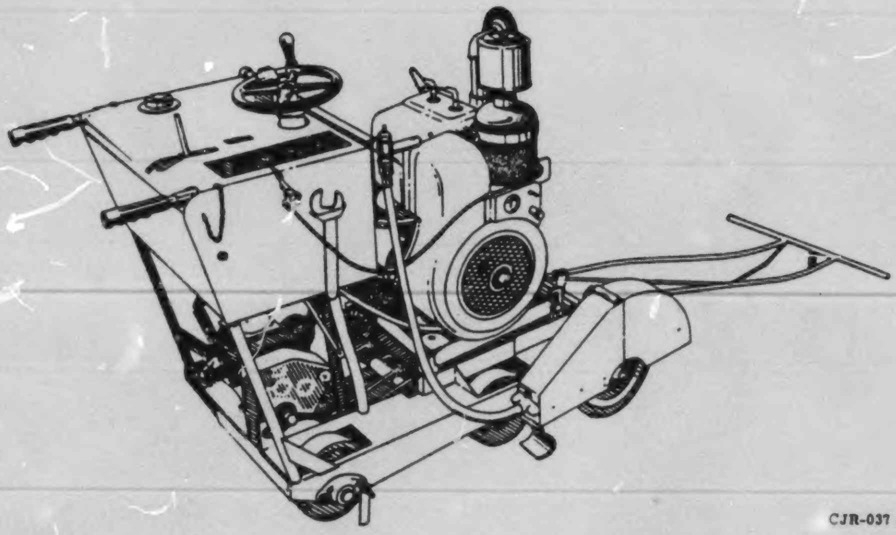


Figure 82. Concrete Saw

16B-74-594

Air Compressor

The air compressor is a piece of equipment that supplies air for operating Pneumatic tools, such as the Pneumatic Tamper and the pavement breaker.

Pavement Breaker

The pavement breaker or "jackhammer," as it is sometimes called, is one type of pneumatic tool. It is operated by air supplied from the air compressor. The pavement breaker is used for breaking up concrete that has to be removed.

Pneumatic Tamper

The pneumatic tamper is another tool that must have compressed air to operate. This tool is used for compacting the base materials used under concrete. Figure 83 shows a pneumatic tamper.

Vibrator Tamper

The vibrator tamper is another that is used for compacting base material used under concrete. Instead of using air to operate on, the vibrator tamper operates by means of a gasoline engine, which makes the foot of the machine vibrate. Figure 84 shows a vibrator tamper.

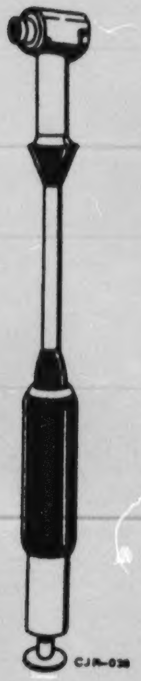


Figure 83. Pneumatic Tamper

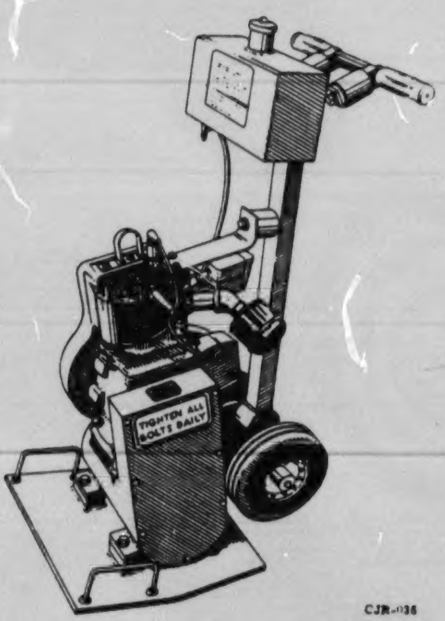


Figure 84. Vibrator Tamper

### Power Trowel

The power trowel is a tool used for finishing concrete. It has three or four steel blades. It does the same job as a cement trowel but much faster, thus allowing more concrete to be finished. Figure 85 shows a power trowel.

### Mortar Mixer

The mortar mixer is used by the block and brick layer to prepare mortar and it is also used by the plasterer to mix plaster. The mortar mixer comes equipped with a gasoline or electric motor. Figure 86 shows a mortar mixer.

### Electric Drill

The electric drill is used by the mason for drilling holes in concrete block and brick and tile. The mason also uses the electric drill to install anchor bolts or to put up bathroom fixtures. Figure 87 shows an electric drill.

### Electric Saw

Electric saws are used by the mason for cutting lumber for forms and for cutting blocks and brick and tile. Electric saws save time and money. You will be taught to operate these saws by your instructor.

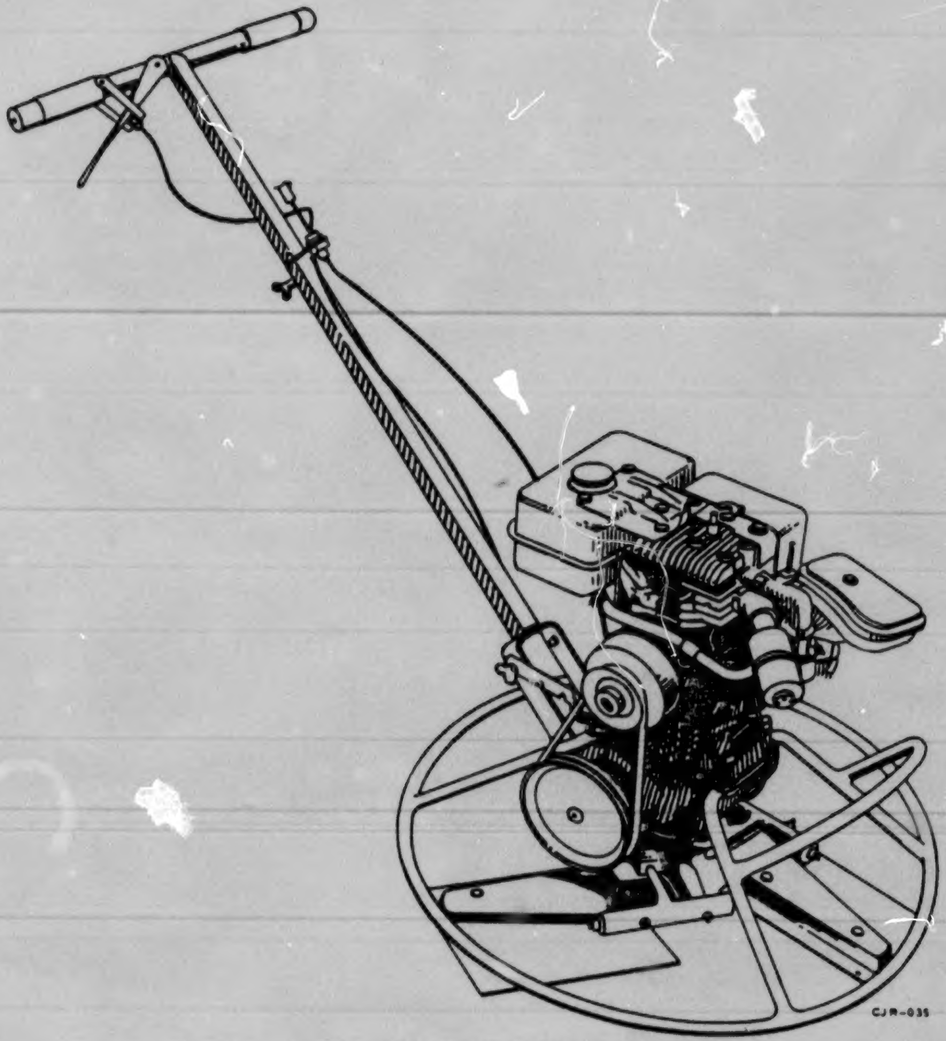


Figure 85. Power Trowel

16F-74-594

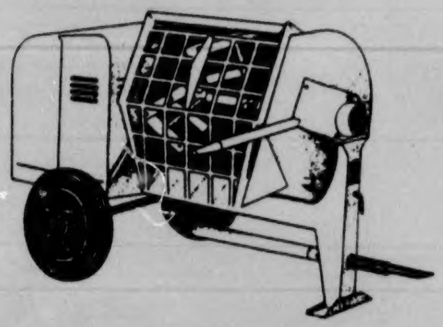


Figure 86. Mortar Mixer

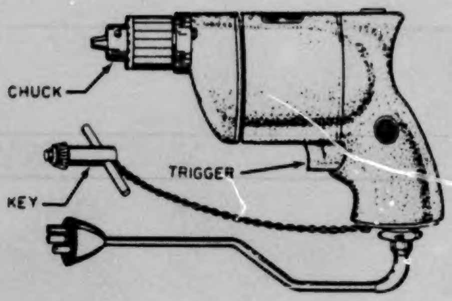


Figure 87. Electric Drill

Safety

The safe use of tools and equipment is an important part of your job. Poor maintenance and the improper use of common hand and power tools result in many accidents which can be avoided if proper safety procedures are followed. One of the most abused rules in the use of tools is: failure to use the right tool for the right job. If you are not familiar with the equipment or procedure you are to perform, check Air Force Manual 127-101, Accident Prevention Handbook, before proceeding.

SUMMARY

There are many types of hand and measuring tools with which you will perform your job. Some of these tools are the screwdriver, hammer, wrenches, chisels, and pliers. Each tool has its own particular application and must be used for that purpose only.

Modern equipment would be useless if accurate measurement and adjustment could not be made. Several types of measuring tools are used for this purpose. In your career field, frequent use of tools such as rules, tapes and wrenches will be necessary.

Tools and equipment must be clean and properly adjusted. Care must be taken to use the proper type and size tool for a particular job. Tools should be stored properly so they will not be damaged while in storage.

Remember, regardless of the type of job to be done, you must select and correctly use the proper tools and equipment in order to do your work quickly and accurately.

## QUESTIONS

1. What type of pliers are usually used for cutting wire?
2. Why must a screwdriver be held firmly against the screw slot?
3. Why is a pipe wrench suitable for turning pipe or round rods and not suitab for use on nuts and bolts?
4. How are tools cared for?
5. What should be done with broken tools?
6. Name one wrench that can be used on several sizes of nuts.
7. What is an Allen wrench?
8. How is grease removed from wrenches?
9. What is the peen end of a ball peen hammer used for?

## REFERENCES

TO 32-1-101, Maintenance and Care of Handtools

TO 32-1-151, Hand Measuring and Power Tools

TO 32-1-171, Engineering Handtools

TO 32A9-2-6-14, Tamper, Backfill, Pneumatic Worthington Model W-8

119

## CONSTRUCTION LAYOUT

### OBJECTIVE

To aid the student in understanding the importance of construction layout in the masonry field.

### INTRODUCTION

Construction layout is an important part of good masonry construction. If buildings are not laid out properly the end product will not be of the proper shape or grade to serve the purposes required by the blueprints. It is important that all layouts be square and level.

### Hub Stakes

Hub stakes are set by the surveyor and serve as a reference for setting up the batter boards.

### Batter Boards

Batter boards are set about three (3) feet from each corner of the project. They hold the strings that determine the exact boundary of the project. If the project is to be a floor for a building, the tops of the batter boards should be even with the level of the floor.

Figure 88 shows batter boards set up.

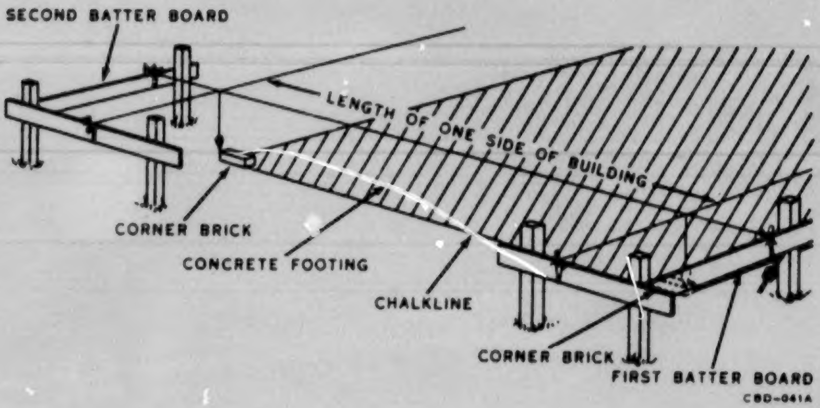

SECOND BATTER BOARD
LENGTH OF ONE SIDE OF BUILDING
CORNER BRICK
CONCRETE FOOTING
CHALKLINE
CORNER BRICK
FIRST BATTER BOARD
CBD-041A

Figure 88. Batter Boards

### Layout Lines

The layout lines are attached to the batter boards. They form the exact dimensions of the project. Figure 88 shows layout lines.

### Plumb Bob

The plumb bob is used to locate exactly the starting point for the corners. The plumb bobs are hung from the strings that are attached to the batter boards where the strings cross to form the corners. Figure 88 shows the location of the plumb bobs.

### Square

The layout lines can be squared by the right-triangle method. This method consists of first measuring 6' from one side of a corner; second, measuring 8' from the other side of the same corner, and third, adjusting the lines until there is 10' between the two points. Figure 89 shows the right-triangle method.

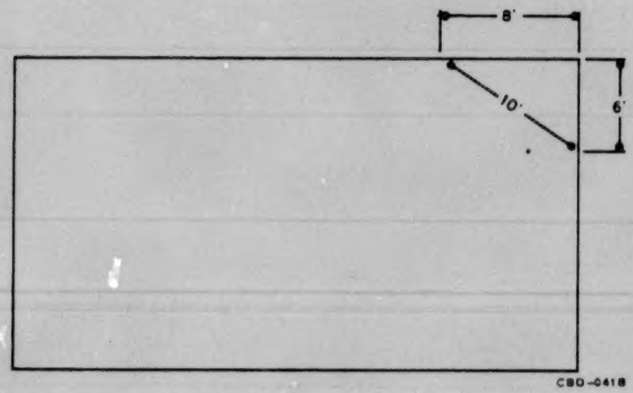


Figure 89. Right-Triangle Method

### Diagonal Checking

Another method of squaring the project is by the diagonal method. When using the diagonal method, use a 50' or 100' tape. Measure diagonally from one corner to the opposite corner on the other end. Do the same with the other corners. Adjust the strings until both measurements read the same. Figure 90 shows this method.

### Level

The batter boards must all be set at the same level. One method of leveling the batter boards is to have it done by a surveyor. Another method that can be used is a water level.

Figure 91 shows how to use the water level.

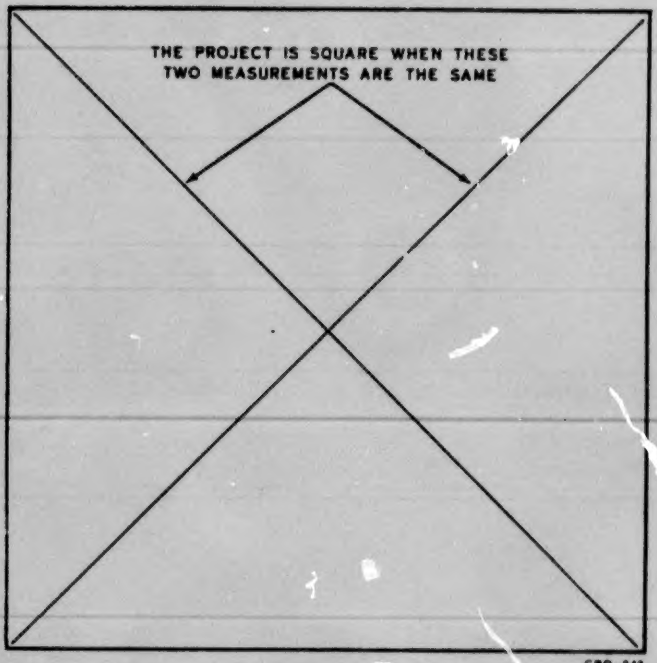

THE PROJECT IS SQUARE WHEN THESE
TWO MEASUREMENTS ARE THE SAME
CBD-042

Figure 90. Diagonal Checking

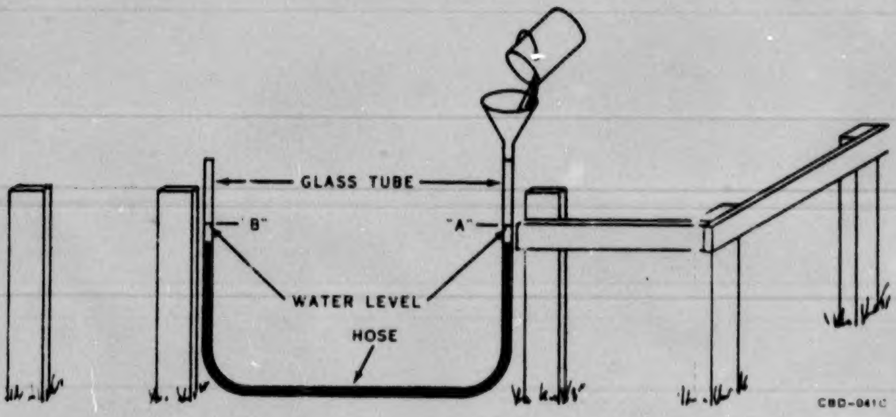

GLASS TUBE
"B"
"A"
WATER LEVEL
HOSE
CBD-041C

Figure 91. Water Level

A. Level one set of batter boards first.
B. Place hose as shown in figure.
C. Fill hose with water until water level is up to the top of batter board "A".
D. Mark the water level at other end of hose "B" and set batter boards to this mark.

SUMMARY

Square and level batter boards are important to good construction. It is your responsibility to insure that all forms are square and level. It is better to spend a few minutes checking to insure that all batter boards and layout lines are level and square than to spend hours or days in redoing a job that was not done properly.

QUESTIONS

1. What is a hub stake?

2. What are batter boards used for?

3. Why is a plumb bob used?

4. What is one method of squaring a project?

5. What is the water level used for?

REFERENCES

AFM 85-1, Resource and Work Force Management
CDC 55253, Masonry Specialist

WORKBOOKS
3ABR55233-I-2-P1 thru 9-P1

3-19

Technical Training

Masonry Specialist

# INTRODUCTION TO MASONRY

December 1975

USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
Department of Civil Engineering Training
Sheppard Air Force Base, Texas

Designed For ATC Course Use

DO NOT USE ON THE JOB

## PURPOSE OF STUDY GUIDES AND WORKBOOKS

Study Guides and Workbooks are training publications authorized by Air Training Command (ATC) for student use in ATC courses.

The STUDY GUIDE (SG) presents the information you need to complete the unit of instruction, or makes assignments for you to read in other publications which contain the required information

The WORKBOOK (WB) contains work procedures designed to help you achieve the learning objectives of the unit of instruction. Knowledge acquired from using the student study guide will help you perform the missions or exercises, solve the problems, or answer questions presented in the workbook.

THE STUDY GUIDE AND WORKBOOK (SG/WB) contains both SG and WB material under one cover. The two training publications may be combined when the WB is not designed for you to write in, or when both SG and WB are issued for you to keep.

Training publications are designed for ATC use only. They are updated as necessary for training purposes, but are NOT to be used on the job as authoritative references in preference to Technical Orders or other official publications.

# MODIFICATIONS

Pages 1-10 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

## SAFETY

### OBJECTIVE

Given a picture containing safety hazards that may be encountered when using or maintaining masonry tools and equipment, identify these hazards and explain how to eliminate them. All hazards must be identified.

Using given procedures, erect a ladder and scaffold so that it complies with all safety regulations.

Exercise safety precautions while lifting a heavy object from the floor to a full upright position. The correct body position must be used and all safety precautions observed.

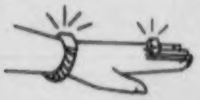
### EQUIPMENT

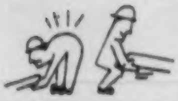
| | Basis of Issue |
|---|---|
| SG 3ABR55233-I-3 | 1/student |
| WB 3ABR55233-I-3-P1 | 1/student |
| Ladder | 1/6 students |
| Scaffold | 1/6 students |

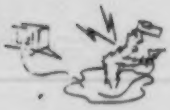
### Mission 1

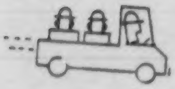
### PROCEDURE

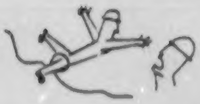
1. Identify each of the following safety hazards. Write your answer in the space provided between the pictures.
2. Explain how to eliminate each safety hazard. Write your answer in the space provided.

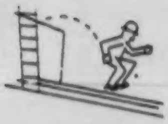


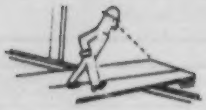


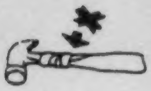


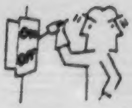








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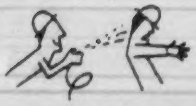

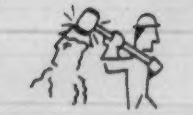

## Mission 2

## ERECTION OF LADDERS

1. Select a stepladder from the storage area and perform the following:
    - a. Visual inspection
        - (1) Parallel rails for cracks
        - (2) Rungs for cracks, breaks
        - (3) Braces and locking devices for security
    - b. Erection
        - (1) Spread front and back sections apart
        - (2) Secure locking device or spreader by pushing it down until it is seated.
        - (3) Insure that ladder is on level surface
    - c. Store ladder by hanging it on rack in a vertical position.
2. Select an extension ladder and perform the following:
    - a. Visual inspection
        - (1) Parallel rails for cracks
        - (2) Rungs for cracks and breaks
        - (3) Locking devices for security
        - (4) Condition of rope and pulley
    - b. Erection
        - (1) Keep the base from slipping, have someone hold it or secure it with rope.
        - (2) Place the base on a firm, level footing, never on movable objects, 1/4 of height of ladder from building.
        - (3) Secure top of tall ladder to structure whenever possible.
        - (4) Insure that the ladder is not in front of a door, busy aisle or street unless someone is attending the bottom footing.
    - c. Store ladder by hanging it on rack horizontally.

## ERECTION OF STAIRWAY SCAFFOLD

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Get base section, 6 platform sections, 2 upper sections, and 1 safety rail section from the storage area. The instructor will designate an area for erecting the scaffold. Before starting the erection procedures, read the special safety rules carefully.

Erect the scaffold according to the instructions and illustrations that follows.

Special Safety Rules - Stairway Scaffolds

1. Never use stairways to work from, but only for personnel to walk up and down between platforms. Stairways are designed to take the weight of a 200-pound man with a factor of safety of 4. However, they are not designed to take severe loads or abuse.

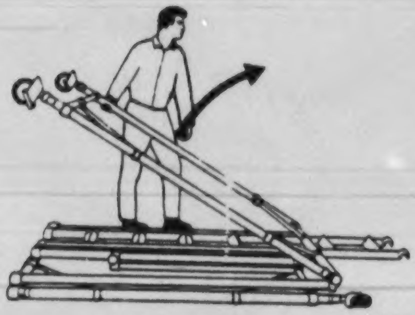
2. Never climb up the outside of a stairway scaffold. Always use the stairway for access.

3. The platform of the stairway scaffold must always be located on the floor braces by means of four locating pins. When being used outdoors, or wherever the scaffold is exposed to wind or updrafts, the platforms must be tied down and the scaffold secured to the building.

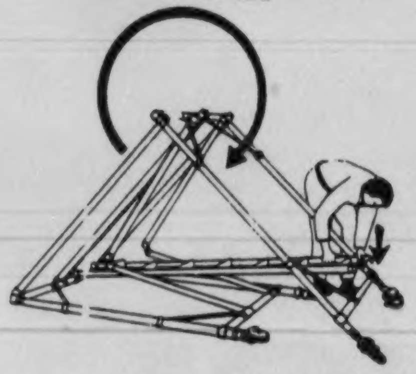
4. The platform of the stairway scaffold is designed to carry a maximum distributed load of 750 pounds with a factor of safety of 4. Do not exceed this 750-pound load.

5. When bridging between scaffolds with planks or ladder stages, place the ends of such planks or stages on the scaffold platform across both floor braces to distribute the load. The other braces of the scaffold are not designed to take heavy loads. The floor braces are the thicker tubes (approximately 1/8" wall) and have vertical pins for locating plywood platforms.

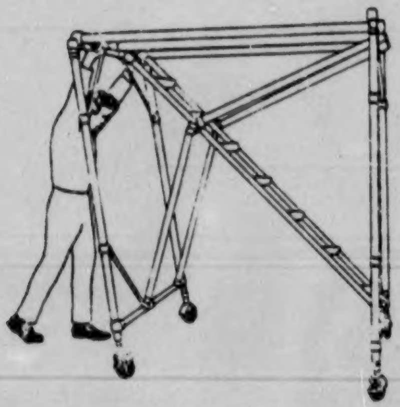
6. When erecting or taking down an upper section of the scaffold, always stand in the center of the platform below, and keep a firm hold on the section. (See the instructional illustrations.)



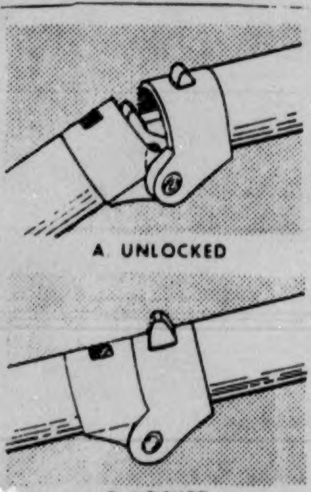
1. Place adjustable section on ground with stairway treads facing up. Swing top end frame over.



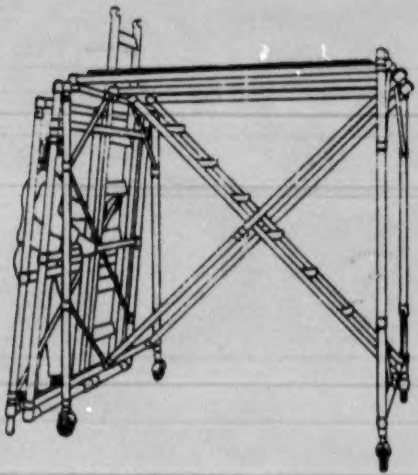
2. Swing end frame through 270° until lower crossbar snaps into hooks at bottom of stairway.



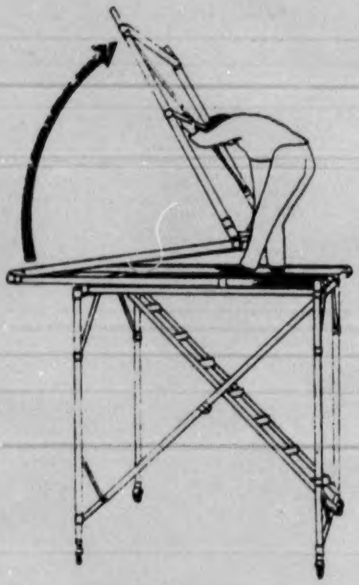
3. Lift opposite end until end frame is vertical and folding V-braces have opened into locking position. Check locking hinges on both V-braces to make sure they are locked.



4. Make sure spring-actuated latches have moved into full locking position before using the scaffold. Do not use the scaffold if any of the latches are not working properly.



5. Lock the casters. Place upper section against top of stairway on bottom section. Stairway on bottom section. Stairway treads should face out.



6. Place upper section on top of lower section as shown with stairway treads facing up. Swing top end frame over.

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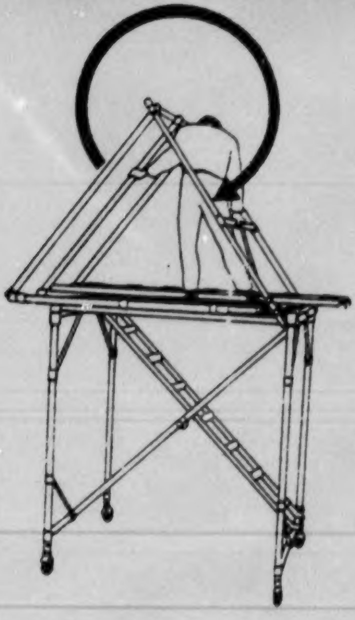
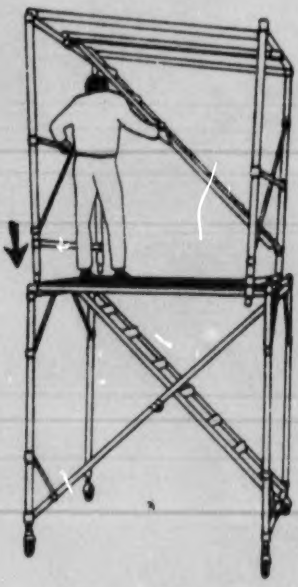
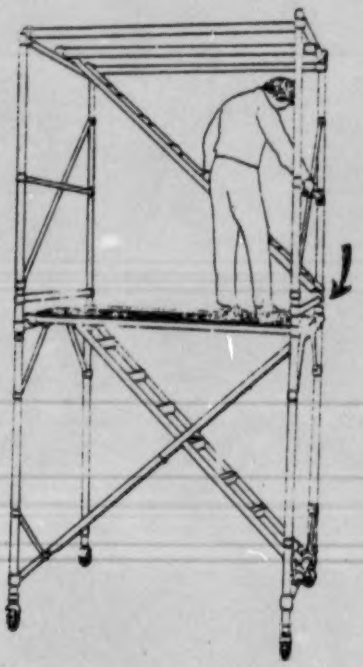


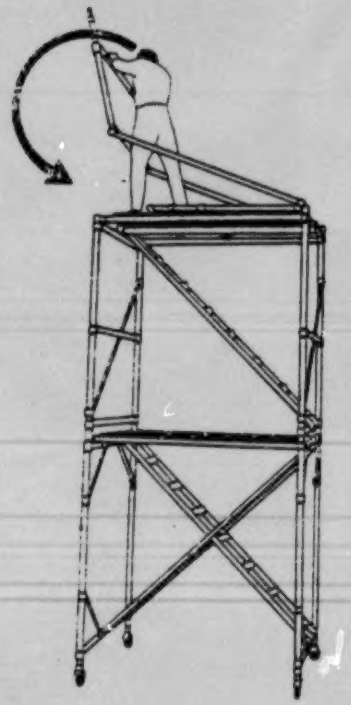
7. Swing end frame through 270° until lower crossbar passes under stairway and straddles floor braces of lower section.



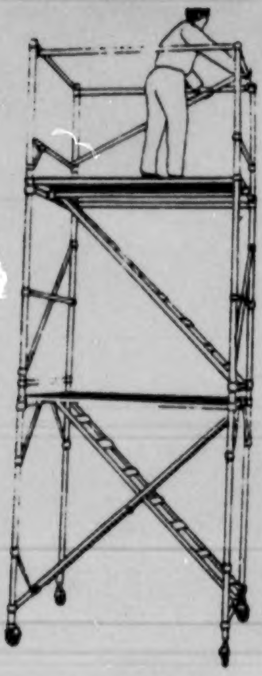
8. Raise floor braces until opposite end frame becomes vertical. Slip frame into sockets.



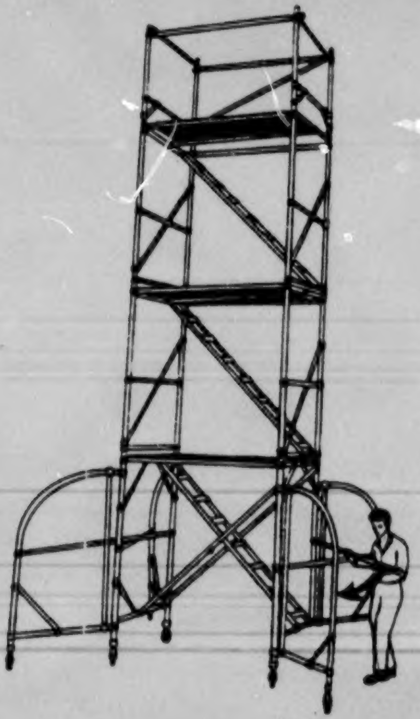
9. Slip other end frame into sockets and lock stairway hooks into position. Place plywood platform over locating pins on supporting tubes. As each section is installed, move interlock clips up to locking holes



10. Place folded half section or safety railing with its longer frame on top at the stairway end. Unfold longer end frame through 270° and slip into sockets.



11. Place opposite end in sockets and snap diagonal brace into position as shown. Place an additional platform over the stairway opening if desired.



12. Before adding a third section, install outboard supports attaching bottom hooks onto scaffold columns below joints. Install diagonal braces as shown.

NOTE: To dismantle the scaffold, reverse the erection procedures.

### Mission III

### LIFTING A HEAVY LOAD

NOTE: The instructor will provide you with a heavy load to lift.

1. Go to the object to be picked up.
2. Assume the correct position to lift the load.
3. Lift the load to a full up right position.
4. Lower the load to its original position.

# MODIFICATIONS

Pages 20-25 of this publication has (have) been deleted in adapting this material for inclusion in the "Trial Implementation of a Model System to Provide Military Curriculum Materials for Use in Vocational and Technical Education." Deleted material involves extensive use of military forms, procedures, systems, etc. and was not considered appropriate for use in vocational and technical education.

# ARITHMETIC PROBLEMS AND ESTIMATING PROCEDURES

## OBJECTIVE

Solve arithmetic problems consisting of whole numbers, fractions, and decimals. All given problems must be solved correctly.

Given a simple sketch of a masonry project, estimate the types and amount of materials and the man-hours required. Estimates must be within -0% + 10% of those found by the instructor.

## EQUIPMENT

| | Basis of Issue |
|---|---|
| SG3ABR55233-I-5 | 1/student |
| WB 3ABR55233-I-5-P1 | 1/student |

## INSTRUCTIONS

Complete the following exercises using either the study guide or class notes as reference.

### Mission 1

### ADDITION

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2 | 4 | 5 | 1 | 9479 | 67856 | 2.18 | 45.56 | 62.2 |
| 8 | 7 | 9 | 4 | 6364 | 22851 | 34.35 | 31.87 | 86.4 |
| 9 | 6 | 9 | 3 | 4269 | 44238 | 0.14 | 13.89 | 27.5 |
| 6 | 7 | 4 | 8 | 9785 | 97156 | 4.90 | .16 | 10.0 |
| 3 | 5 | 9 | 2 | | | | | |

18 + 93 + 51 + 42 = _____

73 + 83 + 96 + 32 = _____

129 + 958 + 787 + 436 = _____

162 + 47 + 391 + 64 = _____

1/2 + 1/4 = _____

3/8 + 5/16 = _____

1/2 + 1/32 = _____

1/64 + 3/8 = _____

Mission 3

## MULTIPLICATION

38 x 23 = ________

42 x 51 = ________

67 x 105 = ________

21 x 176 = ________

312 x 1769 = ________

191 x 1801 = ________

9 x 531 = ________

2153 x 2867 = ________

5/8 x 12 = ________

2/3 x 6 = ________

1/3 x 2/3 = ________

1-5/6 x 13 = ________

10-1/2 x 3-1/3 = ________

7/12 x 3/5 = ________

5.5
3.3
___

0.0073
5.4
___

0.01
6.5
___

Mission 2

## SUBTRACTION

5 - 2 = _____

27 - 14 = _____

390 - 169 = _____

639 - 378 = _____

709 - 594 = _____

| | | | |
|---|---|---|---|
| 3457 | 8752 | 5392 | 75158 |
| 2498 | 4658 | 2807 | 28089 |

1/2 - 1/3 = _____

1/4 - 1/8 = _____

9/16 - 1/2 = _____

3/4 - 2/3 = _____

2-7/8 - 1-1/16 = _____

3-1/4 - 2-1/2 = _____

28-1/3 - 19-1/4 = _____

45.56 - 31.24 = _____

34.82 - 19.99 = _____

78.32 - 51.73 = _____

41.78 - 12.61 = _____

36.47 - 9.08 = _____

397.09 - 283.51 = _____

77.77 - 1.11 = _____

Mission 4

## DIVISION

21 ÷ 3 = ________

108 ÷ 21 = ________

12 ÷ 5 = ________

93 ÷ 3 = ________

107 ÷ 12 = ________

2953 ÷ 92 = ________

3687 ÷ 51 = ________

3/8 ÷ 2/3 = ________

5/8 ÷ 5/16 = ________

3/4 ÷ 3/20 = ________

3-3/4 ÷ 5/8 = ________

4/9 ÷ 1/6 = ________

2-2/3 ÷ 3 = ________

9 ÷ 2/7 = ________

$16\overline{)3}$ $.12\overline{).02958}$ $8\overline{)4.2768}$

$3.5\overline{)30.625}$ $.36\overline{).045}$ $.6\overline{)5.368848}$

## Mission 5

## AREA

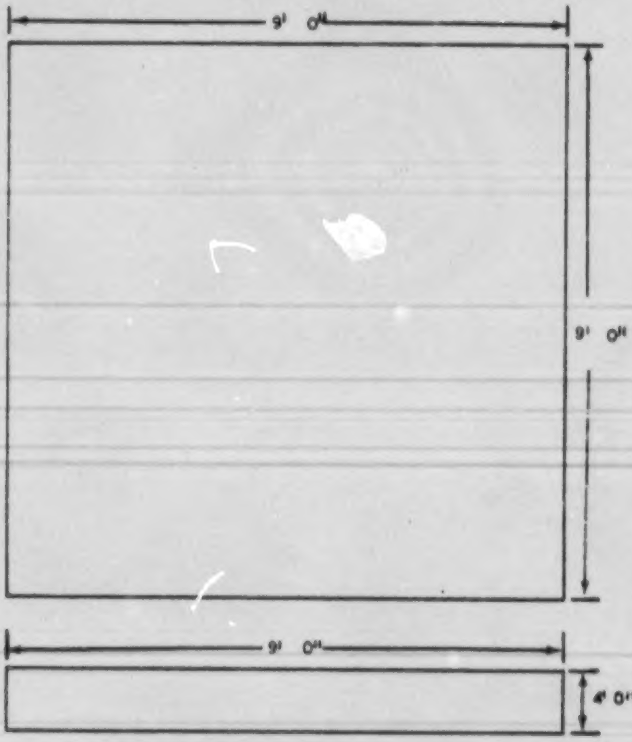
Find the square footage of each of the following problems:

1. A circle with a radius of 21".
2. A square with a 2½' side.
3. A rectangle that measures 10' 6" x 8'.
4. A triangle with a base of 6' and a height of 9'.
5. A circle with a radius of 6' 3".
6. A triangle with a base of 12' and height of 15'.
7. A square with a side 173' long.
8. A rectangle that is 123' long and 107' wide.
9. A triangle with a base of 42' and a height of 86'.

Below is a sketch of a patio to be constructed.

1. Disregarding any loss of water or of material, how many cubic yards of concrete would be required to complete this project?________

2. If an airman can handmix 2 cubic yards in 8 hours, how many hours would be required to accomplish this project?____________



# PLANNING A MASONRY PROJECT

## OBJECTIVE

- Using the assigned engineering drawing, interpret a list of given items. Each item must be interpreted correctly.

- Given the types of lines, symbols, and required scales, prepare a sketch of a masonry project. Finished sketch must be complete enough to use as a working drawing.

## EQUIPMENT

| | Basis of Issue |
|---|---|
| SG 3ABR55233-I-6 | 1/student |
| WB 3ABR55233-I-6-P1 | 1/student |
| Engineering Drawings | 1/student |

## INSTRUCTIONS

### Mission 1

Use your study guide, class notes, and some engineering drawings given to you by your instructor to complete the following:

1. Plot Plans

What information is given in plot plans?

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ______________________________

f. ______________________________

(1) ______________________________

(2) ______________________________

(3) ______________________________

2. Foundation Plans (Use drawing number 25-074/3)

a. K-3 - What is the size of the footing? ____________

b. H-3 - What size reinforcement steel is used? ____________

c. Latrine #4 - What is the size of the concrete slab? ____________

(1) Thickness ____________

(2) Length ____________

(3) Width ____________

3. Framing Plans (Use drawing number 25-074/3)

a. N-3 - What is the size of the floor joist? ____________

What is the center spacing? ____________

b. K-3 - What type of floor covering will be used?

______________________________

c. E-3 - What is the size of the blocking? ____________

4. Floor Plans (Use drawing number 119-58)

   a. What is the building dimensions? ____________________

   b. How many sets of double doors are there? ____________

   c. What is the width of the sliding door? ______________

   d. What is the width of the double doors? ______________

      (1) East ____________________

      (2) West ____________________

5. Elevations (Use drawing number AW 21-01-03, plate 27)

   a. What is the elevation of the kitchen floor? __________ ft.

   b. What is the height of the ceiling of the dishwashing room?

      ____________________

   c. Window spacing for court A, what type glass is used?

      ____________________

   d. Using elevation number 3, what type of materials are used for the facing? ____________________

6. Selections and details (Drawing number AW 21-01-03, plate 28)

   a. Section 2 - What are the different sizes of concrete masonry units used?

      (1) ____________________

      (2) ____________________

   b. Section 2 - Horizontal reinforcement will be tied on

      ____________________ centers.

c. Section 7 - What type of windows are used?

________________________________________

d. Section 11 - How far apart are weep holes drilled?

________________________________________

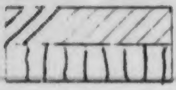
7. Drawing Techniques (Details)

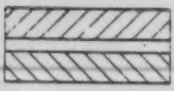
a. ____________________________
b. ____________________________
c. ____________________________
d. ____________________________
e. ____________________________
f. ____________________________
g. ____________________________

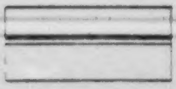
8. Symbols and Terms

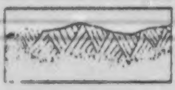
Use your study guide and class notes to fill in the blanks.

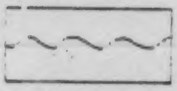
a. Symbols:

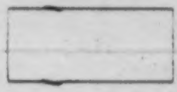
(1)  ______

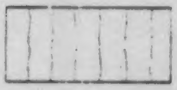
(2)  ______

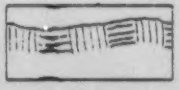
(3)  ______

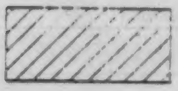
(4)  ______

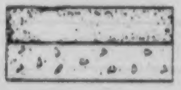
(5)  ______

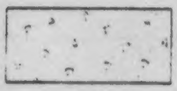
(6)  ______

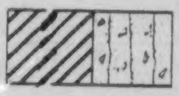
(7)  ______

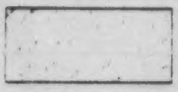
(8)  ______

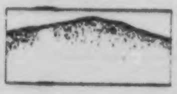
(9)  ______

(10)  ______

(11)  ______

(12)  ______

(13)  ______

(14)  ______

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# MAINTENANCE OF TOOLS AND EQUIPMENT

## OBJECTIVE

- Working as a member of a six-man team and using a school technical order file, clean, sharpen, repair, and maintain masonry tools and equipment. All work must comply with TO 32-1-101.

- Working as a member of a six-man team and using course equipment and instructions provided by technical orders and check lists, perform preoperational inspections on various types of masonry tools and equipment. All work must be conducted in a safe manner and comply with the equipment's technical order.

## EQUIPMENT

| | Basis of Issue |
|---|---|
| SG 55233-I-8 | 1/student |
| WB 55233-I-8-P1 | 1/student |
| TO 32-1-101 | 1/student |
| TO 32-1-151 | 1/student |
| TO 32-1-171 | 1/student |
| TO 3ZA9-2-6-14 | 1/student |
| Pencils | 1/student |
| Concrete Mixer | 1/12 students |
| Mortar Mixer | 1/12 students |
| Concrete Saw | 1/12 students |
| Tile Saw | 1/12 students |
| Air Compressor | 1/12 students |
| Paving Breaker | 1/12 students |
| Pneumatic Breaker | 1/12 students |
| Electric Drill | 1/12 students |
| Vibrator | 1/12 students |
| Power Trowel | 1/12 students |
| Bolt Cutter | 1/6 students |
| Crosscut Handsaw | 1/6 students |
| Electric Saw | 1/6 students |
| Tin Snips | 1/6 students |
| Hand Axe | 1/6 students |
| Brick Set | 1/6 students |
| Brick Hammer | 1/6 students |
| Tile Nipper | 1/6 students |
| Pick | 1/6 students |

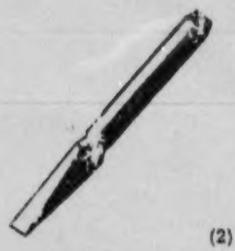
| EQUIPMENT (continued) | Basis of Issue |
|---|---|
| Space | 1/6 students |
| Star Drill | 1/6 students |
| Brace and Bit | 1/6 students |
| Level | 1/6 students |
| Plumb Bob | 1/6 students |

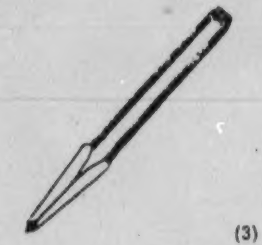
**PROCEDURE**

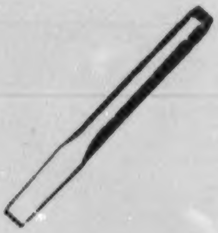
### Mission 1

1. Use TO 32-1-101, your Study Guide or class notes; complete the following:

CHISELS:


(1)


(2)


(3)

a. The three chisels pictured above are:

(1) ______________________________

(2) ______________________________

(3) ______________________________

b. If you wanted to cut a piece of flat metal, which one of the chisels would you select? ____________________

c. Before chisels are stored, apply ________________ and protect the cutting edge from ____________________

______________ ____________________

d. When chisels are removed from storage, rust-preventive compound should be removed with ____________________

____________________________________________.

2. SAWS:

a. A crosscut saw is used to cut ____________ the grain, and

a rip saw is used to cut ________________ the grain.

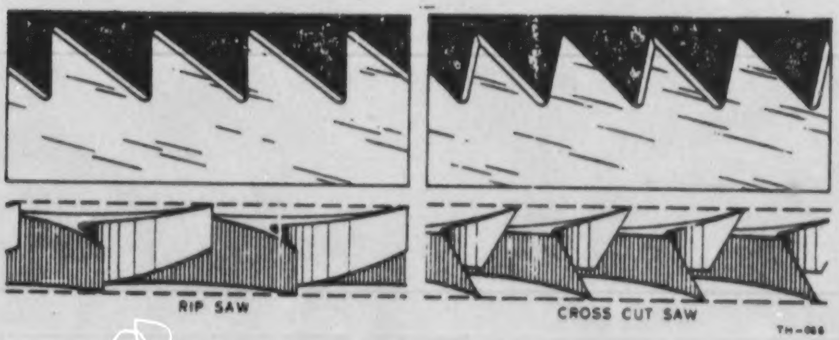
b. After using a saw, always oil the blade with a ____________

____________________________________________.

c. If rust appears on the blade, remove with a ______________

and apply a ____________________________________.

d.



Rip saw teeth are shaped and filed to cut like ____________

while the teeth of a crosscut saw cut like ____________.

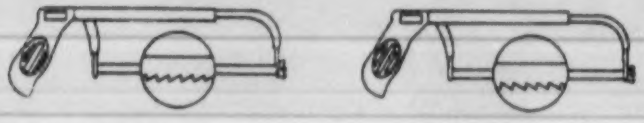
e. The two types of hacksaw frames are:

(1) ____________________________________.

(2) ____________________________________.

f. A ____________________ blade is used for cutting hard metal, and a ____________________ blade would be used for cutting soft metal.

g.

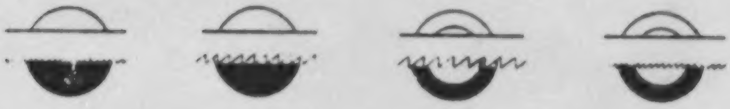


TC-[illegible]

In the drawing above, the blade in the hacksaw on the __________ is installed correctly since it will cut on the ______________ stroke.

h. When using a hacksaw, there should always be at least __________ ____________________ teeth in contact with the metal.

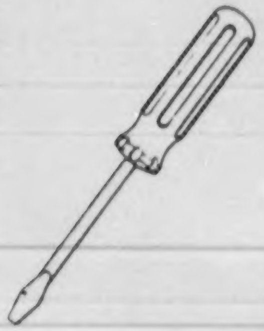
i. In the drawing below indicate which blade selection is correct and which is wrong.

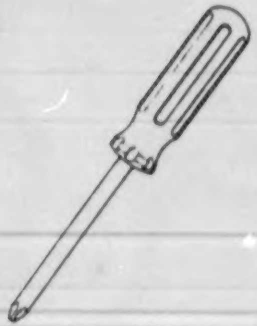


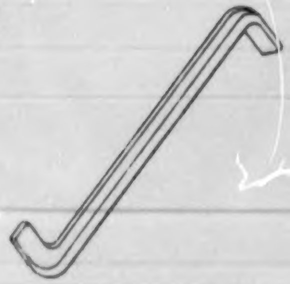
(1) __________ (2) __________ (3) __________ (4) __________

### 3. SCREWDRIVERS:

a. **The screwdrivers shown below are:**

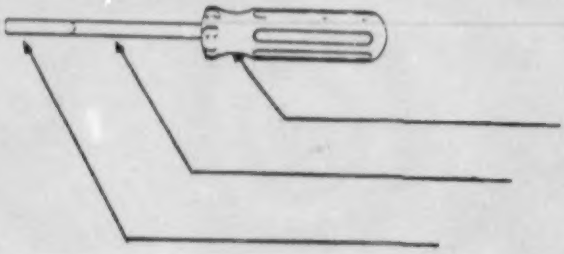






(1) ______________ (2) ______________ (3) ______________

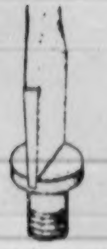
b. **The parts of a screwdriver are:**



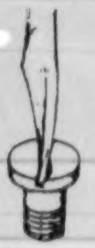
c. **The size of a screwdriver is determined by measuring the**

______________ and the ______________.

d.



(1)



(2)

(1) Shows ______________________________________.

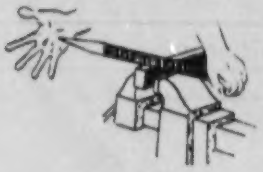
(2) Shows ______________________________________.

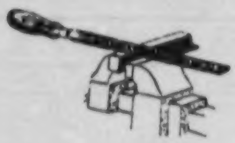
4. FILES:

a. Files are used to ______________________________

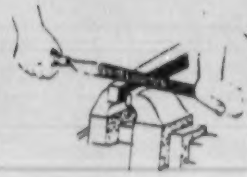
______________________________________________.

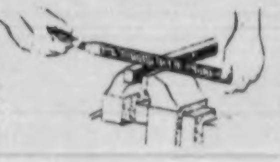
b. Files should never be used without a ______________.





c.



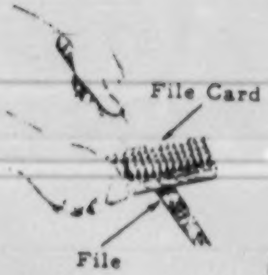


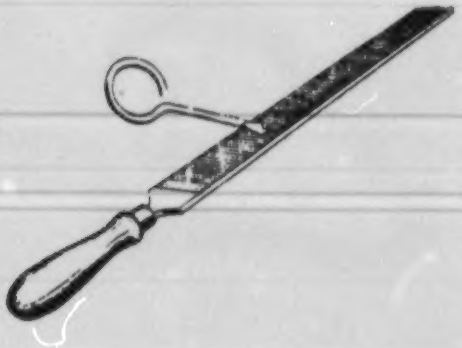
Correct use of a file is shown in the drawing on the __________.

d. Excessive pressure while filing results in ____________________

and ____________________ teeth.

e.

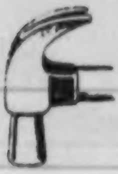




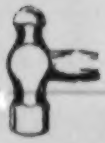
The drawing on the left above shows how a file is cleaned with a ____________________ ____________. Metal particles are also removed from a file as shown in the drawing on the right with a ____________________.

5. HAMMERS:

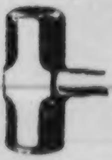
a.



(1)



(2)



(3)

The hammers shown above are:

(1) ____________ Purpose ____________

____________

____________

____________

(2) ____________ Purpose ____________

____________

____________

____________

(3) ____________ Purpose ____________

____________

____________

____________

(7) Name__________ Purpose____________________

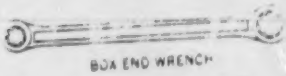
____________________

(8) Name__________ Purpose____________________

____________________

b. Give the purpose of each of the following:

(1) Purpose____________________

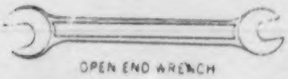


BOX END WRENCH

____________________

____________________

(2) Purpose____________________

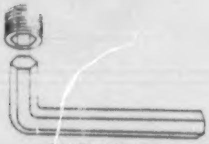


OPEN END WRENCH

____________________

____________________

(3) Purpose____________________



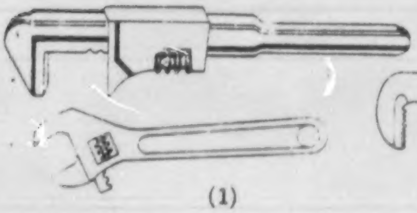
ALLEN WRENCH

____________________

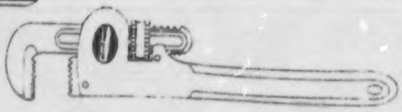
____________________

____________________

c.



(1)



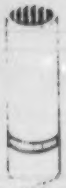
(2)

The types of wrenches shown above are:

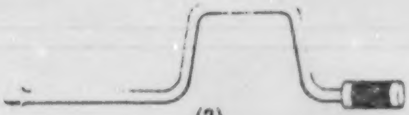
(1) ________________________________________

(2) ________________________________________

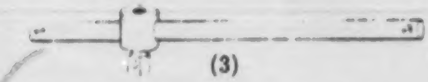
6. WRENCHES:



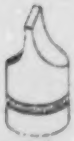
(1)



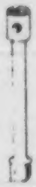
(2)



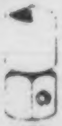
(3)



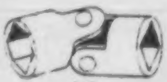
(7)



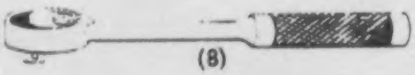
(4)



(5)



(6)



(8)

a. From the drawing above, give the name and purpose of the following:

(1) Name______________ Purpose______________________

______________________

(2) Name______________ Purpose______________________

______________________

(3) Name______________ Purpose______________________

______________________

(4) Name______________ Purpose______________________

______________________

(5) Name______________ Purpose______________________

______________________

(6) Name______________ Purpose______________________

______________________

d. Dirt and grease should be removed from wrenches with ________

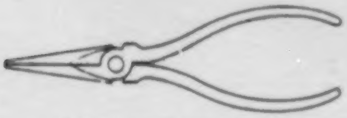
________ ________.

Scour rust from wrenches with ________

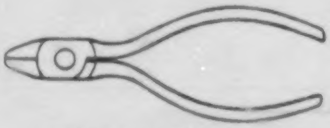
or ________.

7. PLIERS:

a. In the space provided for each illustration below, give the purpose of each tool:



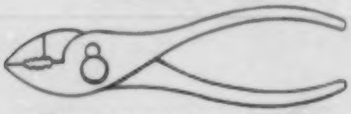
Long-Nose Pliers



Diagonal Pliers

Purpose ________ Purpose ________

________ ________



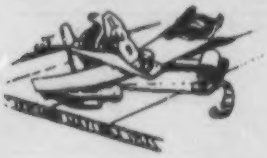
Combination Slip-Joint

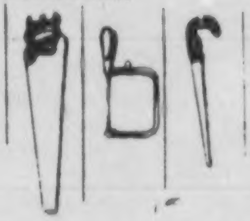
Purpose ________

________

8. Use and Storage of Handtools:

NOTE: Test your knowledge on the use and storage of handtools by writing RIGHT or WRONG under each illustration.





a. ________ b. ________

# LAYING OUT A BUILDING FOR MASONRY CONSTRUCTION

## OBJECTIVE:

Working as a member of a six-man team and using the assigned materials, area, hand tools, and workbook, lay out a building within a tolerance plus or minus 1/4 inch.

| Equipment | Basis of Issue |
|---|---|
| SG 3ABR55233-I-9 | 1/student |
| WB 3ABR55233-I-9-P1 | 1/student |
| 50-foot steel tape | 1/4 student |
| 6-foot rule | 1/student |
| 2 x 4 and 1 x 4 | 1/4 student |
| Sledge hammer | 1/4 student |
| Electric saw | 1/4 student |

## PROCEDURES

1. Lay out a rectangular building (see figure 5) 20-feet long and 10-feet wide.
2. Procure necessary tools and equipment.
3. Go to the area designated by the instructor.
4. Position the hub stakes.
5. Set the batter boards as shown in figure 91, SG 3ABR55233-I-9.
6. Level the batter boards. Use either the water hose or the 4-foot level method.
7. String the layout lines.
8. Check the layout lines for accuracy. Use the diagonal checking method.
9. Use a plumb bob to transfer the hub stake points.
10. Have the instructor check your work.
11. Follow the same procedures and lay out a building with an offset (see figure 6).
12. Follow the sampe procedures and lay out a U-shaped building (see figure 7).

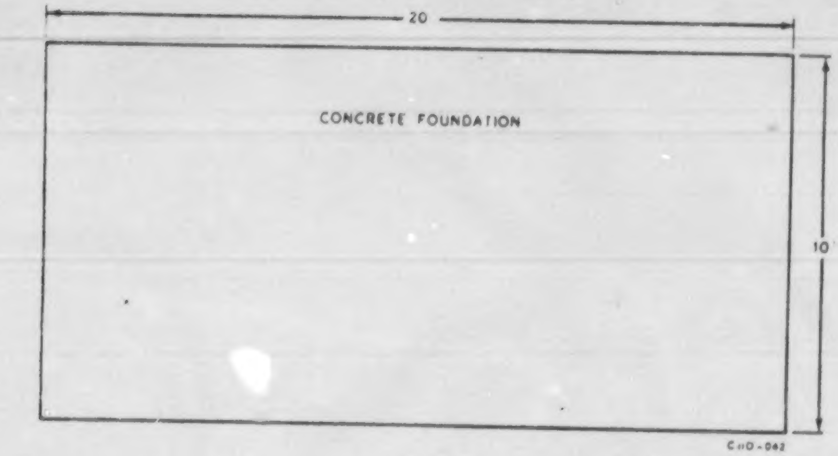

20
CONCRETE FOUNDATION
10'
CBO-042

Figure 5. Rectangular Building

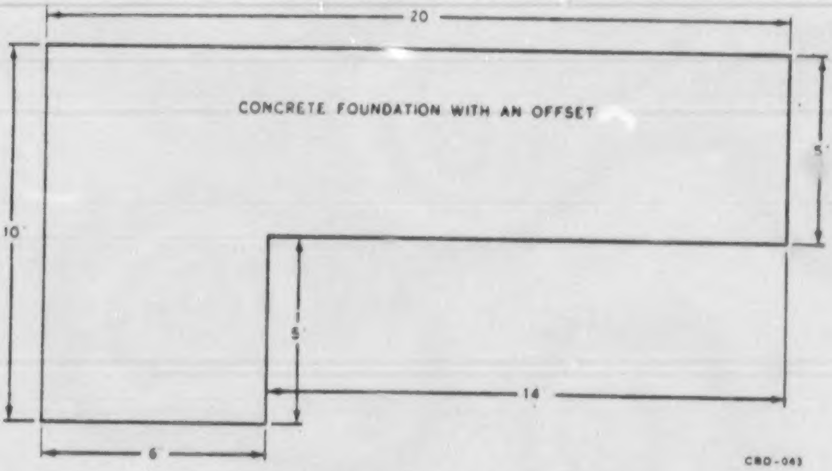

20
CONCRETE FOUNDATION WITH AN OFFSET
5'
10'
5'
14
6
CBO-043

Figure 6 Building with Offset

161

2TPT-5111-02

3-19

Technical Training

# Basic Mathematics - Decimals

April 1967

SHEPPARD AIR FORCE BASE

Original Material Prepared
by
Naval Air Technical Training Command

Designed For ATC Course Use

## ANSWERS TO SELF-TEST

## DECIMALS

1. A decimal is a number that represents a fraction with a denominator that is a power of ten.

2. a. (30.04 thirty and four hundredths)
   b. (.379 three hundred seventy-nine thousandths)
   c. (1.46 one and forty-six hundredths)
   d. (90.001 ninety and one thousandths)

3. a. 9.75 b. 12.3 c. 7.123 d. .0073

4. a. .3 b. .8 c. .75 d. 2.5

5. a. $\frac{1}{4}$ b. $\frac{9}{10}$ c. $\frac{21}{200}$ d. $\frac{7}{20}$

6. a. .6 b. 13.85 c. .057 d. 1.6001

7. a. 25.886 b. 180.553 c. 19.3925

8. a. 10.18 b. .6298 c. 446.37

9. a. .3093 b. .00284 c. .32012

10. a. 20 b. .001 c. .5

## INSTRUCTIONS

## DECIMALS

This is a programmed lesson on DECIMALS. It is not a test as one might think, but an easy way to learn at your own rate of speed.

The two types of programming used in this lesson are:

a. Linear-- Information, in small amounts, will be presented in sequence. You will advance from frame to frame, using a provided cardboard to cover upcoming frames. Do not look ahead at answers. IF YOU MAKE AN ERROR, strike out the incorrect answer and correct it.

b. Branching-- The information given in these frames will be greater and you will be given a list of possible answers. Directions to turn to a page for each answer will be found next to the answers. FOLLOW THESE DIRECTIONS. Circle the answer you think is correct. If you have selected an incorrect answer, put an X through the incorrect response and circle another answer.

READ ALL INFORMATION CAREFULLY. Be sure you understand what is said before you attempt an answer.

If you wish, you may turn back to any part of the program to clarify some vague point.

While working problems in the program, if you are instructed to SHOW ALL WORK, you must work in the program. Otherwise, you may do the work EITHER on scratch paper or in the program.

Continue to page iii

# DECIMALS

OBJECTIVES:

1. Write, in his own words, the definition of a decimal.
2. Demonstrate ability to read decimals by matching numerical decimals with the appropriate word decimals.
3. Write the numerical form of given word decimals.
4. Change given fractions to decimals.
5. Change given decimals to fractions. Reduce the fractions to lowest terms.
6. Round off given decimals.
7. Add given decimals.
8. Subtract given decimals.
9. Multiply given decimals.
10. Divide given decimals.

SUGGESTED READING TIME— 62 MINUTES

NAME ____________________ CLASS ______________

Continue to page 1.

| | |
|---|---|
| | 1. The definition of a decimal is: A number that represents a fraction with a denominator that is a power of ten. The definition of a decimal is: ______________________________ ______________________________. |
| a number that represents a fraction with a denominator that is a power of ten | 2. Being a power of ten simply means that you can divide ten into the number evenly. The fraction $\frac{47}{100}$ has a denominator of one hundred and, of course, ten will divide evenly into it. We know that 100 is a power of __________. |
| 10 or ten | 3. All decimals represent fractions and in every case the denominator is a power of ten. The decimal, .1, represents the fraction $\frac{1}{10}$. The denominator is a __________ of __________. |
| power<br>ten | 4. The definition of a decimal is: A number that represents a fraction with a __________ that is a __________ of __________. |
| denominator<br>power<br>ten | 4A. Key words often help you remember hard to learn definitions. In the definition of DECIMAL, the words to remember as keys are: FRACTION, DENOMINATOR, and POWER OF TEN.<br>Write the key words that will help you remember the definition of decimal.<br>__________, __________, and __________. |

Continue to page 2.

| | |
|---|---|
| fraction<br>denominator<br>power of ten | 5. A decimal is a number that represents a ____________ with a ____________ that is ______________________________. |
| fraction<br>denominator<br>a power of ten | 6. Write, in your own words, the definition of a decimal ______________________________ ______________________________. |
| a number that represents a fraction with a denominator that is a power of ten (or a reasonable facsimile). | 7. Each digit in a decimal has a place value and is read in a certain way. The places are as follows:<br>.12345<br>1 Tenths<br>2 Hundredths<br>3 Thousandths<br>4 Ten Thousandths<br>5 Hundred Thousandths<br>The 3 is in the thousandths place, the 5 is in the hundred thousandths place, and the 1 is in the ____________ place. |
| tenths | 8. As you probably have noticed, the places to the right of the decimal point all end in "ths." In the decimal 2.46, the 6 is in the ____________ place. |
| hundredths | 9. A decimal is read like this: (Example)<br>35.362-- "Thirty-five AND three hundred sixty-two thousandTHS".<br>The 2 in this decimal is in the ____________ place. |

Continue to page 3.

| | |
|---|---|
| thousandths | 10. When there is a whole number and a decimal, the decimal point is read "AND". For example: 6.02 is read "six AND two hundredths".<br>When there is only a decimal (no whole number), it is read without using the word, "and". For example: .06 is read "six hundreths".<br>How would "thirty-three THOUSANDTHS" be written as a decimal? ______________. |
| .033 | 11. REMEMBER-- When you are reading decimals, the decimal point is read "and" except when there is NO whole number. For example: .5 is read "five tenths". 3.22 is read "three AND twenty-two hundredths".<br>Match the decimal in column A with the correct word decimal in column B, placing the correct letter by the word decimal.<br>A<br>a. 4.3<br>b. .006<br>c. 25.01<br>________Six hundreds<br>________Twenty-five and one hundredth<br>________Six hundredths<br>________Four and three tenths<br>________Twenty-five and one tenth<br>________Six thousandths |

Continue to page 5.

4A

Very good! You should be ready for a more difficult problem, so let's do this one:

Change $\frac{12}{23}$ to a decimal.

| If your answer is: | Go to page: |
|---|---|
| .0052 | 6A |
| .52 | 8B |

---

4B

Wrong!! You add only the number of zeros that there are digits in the decimal. There is only one digit in the decimal .7, so there will be only one zero in the fraction. The decimal .679 has three digits, so the denominator will have three zeros and look like:

| If your answer is: | Go to page: |
|---|---|
| 679/1000 | 16A |
| 679/000 | 8C |

a. 4.3 (four and three tenths)

b. .006 (six thousandths)

c. 25.01 (twenty-five and one hundredth)

12. Now, match column A with column B in the same manner.

| A | | B |
|---|---|---|
| a. .25 | _______ | Two hundredths |
| b. .002 | _______ | One and two hundred twenty-two thousandths |
| c. 20.05 | _______ | Twenty-five hundredths |
| d. 1.222 | _______ | Two thousandths |
| | _______ | Twenty and five hundredths |
| | _______ | Twenty-five hundred |
| | _______ | One and two hundred twenty-two thousands |

---

a. .25 (twenty-five hundredths)

b. .002 (two thousandths)

c. 20.05 (twenty and five hundredths)

d. 1.222 (one and two hundred twenty two thousandths)

NOTE:
Be certain the word decimal ends with "ths."

13. When writing a decimal, FIRST and MOST IMPORTANT, determine the "place" value (thousandths, tenths etc.). This will give you the number of digits you need to the right of the decimal point. For example: twenty-two thousandths will require three digits because it is to the thousandths place. It would be written: .022. Five and five tenths would be written: 5.5(Remember, with a whole number, the decimal point is read AND.)

How would twenty-five and four thousandths be written? ____________

Continue to page 7.

6A

Wrong. You set your division up incorrectly. The problem should have been set up like this: $23/\overline{12.000}$

Return to page 4A and do the division again and place the decimal point in the right position; then select the right answer and go to the page indicated.

6B

3/4 is not correct; .75=3/4. Return to page 10 and work the problem again. Then select the correct answer and continue with the program.

6C

You have misplaced the decimal point. The decimal point ALWAYS goes to the extreme right of the dividend. EXAMPLE: $/\overline{12}$. not $/\overline{1.2}$, from $\frac{12}{7}$. Return to page 8B; rework the problem and continue with the program.

6D

Your division is right, but it is unnecessary to put the 0 at the end of the decimal. Turn to page 4A and continue the program.

| | |
|---|---|
| 25.004 | 14. Thirteen and four tenths would appear as 13.4 .<br>Nine and forty-four hundredths appear as:<br>____________ |
| 9.44 | 15. Four ten thousandths looks like ____________. |
| .0004 | 16. Write the numerical form of twenty-nine thousandths.<br>____________ |
| .029 | 17. Write the numerical form of each of the following word decimals.<br>a. Sixty-five hundredths<br>____________<br>b. Sixty and ninety-seven thousandths<br>____________<br>c. Three hundred and four tenths<br>____________<br>d. Seventy-five ten thousandths<br>____________<br>e. Fifty-eight and sixty-six hundredths<br>____________<br>f. Forty-nine thousandths<br>____________ |

Continue to page 9.

8A

$\frac{45}{1000}$ is correct for the first step, but each fraction must be in its lowest terms. 5 divides into 45 and 1000-- thus it can be reduced. Go back to page 16A and reduce the fraction, choose the correct answer, and go to the page indicated.

8B

.52 is correct. You have been changing proper fractions to decimals, so now let's change an IMPROPER FRACTION to a decimal. It is done in the same manner, but NOW the answer will include a whole number. For example: $\frac{3}{2}$ changed to a decimal is

$$\begin{array}{r} 1.5 \\ 2\overline{)3.0.} \\ \underline{2\phantom{.0.}} \\ 1\ 0 \\ \underline{1\ 0} \end{array}$$

. As you can see, an improper fraction will become a whole number and a decimal (1.5). Change $\frac{12}{7}$ to a decimal.

| If your answer is: | Go to page: |
|---|---|
| .17 | 6C |
| 1.7 | 18A |

8C

You have the 3 zeros but what happened to the 1? The decimal .679 is read "six hundred seventy-nine thousandths," so the denominator becomes 1000. Return to page 4B and select the correct answer.

a. .65
b. 60.097
c. 300.4
d. .0075
e. 58.66
f. .049

18. All fractions can be changed to a decimal by dividing the numerator by the denominator. The decimal may be carried out as many places as the problem indicates. Example: $\frac{7}{8}$ to a decimal is

$$\begin{array}{r} .875 \\ 8\overline{)7.000} \end{array}$$

BROKEN INTO STEPS

a. Divide the numerator (7) by the denominator (8).

b. Place the decimal point to the right of the numerator.

c. Add zeros to the right of the decimal point as needed.

d. Place a decimal point in the quotient DIRECTLY over the decimal point in the division bracket.

e. Carry the quotient out as far as necessary.

Change $\frac{1}{2}$ to a decimal.

| If your answer is: | Go to page: |
|---|---|
| 2.0 | 16B |
| .5 | 4A |
| 5.0 | 18C |

If you are reading this paragraph, then you are not following directions. From here on, you must follow the directions given in each frame VERY CAREFULLY. Return to the frame above and follow the directions given there.

ANSWERS TO PAGE 18A: a. .8 b. 5.2 c. .8 d. 1.3

You have learned how to change a fraction to a decimal, so let's change a decimal into a fraction. The FIRST thing to do is to make the digits of the decimal the NUMERATOR OF THE FRACTION. The denominator of the fraction will have a one (1) followed by the same number of zeros as there are digits in the decimal. For example, the decimal .27 becomes the fraction $\frac{27}{100}$. Notice how the digits 27 become the numerator and the denominator begins with a 1 and two zeros follow. There were two digits in the decimal, thus there are two zeros in the denominator. Change .7 to a fraction.

| If your answer is: | Go to page: |
|---|---|
| $\frac{7}{100}$ | 4B |
| $\frac{7}{10}$ | 16A |
| $\frac{3}{4}$ | 6B |

11A

Fine. As you have done on this problem, make sure that any fraction you are working with is in its lowest terms. Change the following decimals to fractions. Remember, REDUCE each to its lowest terms. If you still are not certain of just how to change decimals to fractions, go back to page 10 and rapidly review.

Change these to fractions:

a. .7000--

b. .009--

c. .75--

d. .2--

Turn to page 12 for answers.

---

11B

You neglected the decimal point. You must place decimal points DIRECTLY UNDER EACH OTHER. The sum will have the decimal point carried right down into it from the column being added. Return to page 17A and do the problem again. Remember to put the decimal points under each other. EXAMPLE:

$$\begin{array}{r@{.}l} 18 & 6 \\ & 015 \\ 2056 & 11 \\ +\quad 1 & 1 \\ \hline 2075 & 825 \end{array}$$

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ANSWERS TO PAGE 11A: a. $\frac{7}{10}$ b. $\frac{9}{1000}$ c. $\frac{3}{4}$ d. $\frac{1}{5}$

Continue your lesson in frame 19 below.

|  |  |
|---|---|
|  | 19. In many cases, a large cumbersome decimal is not necessary. In those cases where a smaller decimal will do, you may ROUND OFF the decimal. To make a large decimal smaller and easier to use without losing a great deal of accuracy, you will ____________ ____________ the large decimal. |
| round off | 20. Rounding off involves THREE steps. The FIRST TWO are:<br>a. Determine the PLACE you want to round off to. (Tenths, hundredths, etc.)<br>b. Look FIRST at the number (digit) DIRECTLY to the right of that place.<br>Example: .176<br>To round to hundredths: First look at the number to the right of the hundredths place. In this case, it is a 6.<br>The FIRST number that you will look at when rounding .265 to TENTHS is ________ (number). |

Continue to page 13.

| | |
|---|---|
| 6 | 21. You have the decimal .27364, and you want to round it off to tenths. What number would you look at first? (Circle your choice.)<br>a. 2<br>b. 7<br>c. 3<br>d. 6<br>e. 4 |
| 7 | 22. The THIRD STEP is:<br>If the number to the right of the place you are rounding off is 5 OR MORE, you ADD (+1) one to the place and drop the remainder of numbers.<br>For example: .176<br>This decimal rounded to tenths becomes .2 because the number to the right of the tenths place (7) is 5 or greater. Also note that the 7 and 6 were dropped.<br>Round .0074 to the nearest HUNDREDTH. (Circle your answer.)<br>a. .01<br>b. .007<br>c. .1<br>d. .08 |
| .01 | 23. When the number to the right is LESS THEN 5, leave the place value as is and DROP THE REMAINDER OF THE NUMBERS.<br>Round the decimal .7848 to hundredths. (Circle your answer.)<br>a. .78 b. .79 c. .785 d. .7800 |

Continue to page 14.

.78

24. REMEMBER:

a. FIRST, look at the number to the right of the place you are rounding off.

b. If the number is 5 or more, add 1 to the place.

c. If less then 5, do not add anything.

d. Always drop the remainder of digits to the right of the rounded off place.

Round these decimals to the indicated places:

Tenths: .408062 ____________

Hundredths: .408062 _________

Thousandths: .408062 ___________

Ten Thousandths: .408062 ___________

Hundred Thousandths: 408062 ___________

.4
.41
.408
.4081
.40806

25. Round off the following decimals:

To Hundredths:

41.1145-- _________

.98509-- _________

To Tenths:

.6419-- __________

To Ten Thousandths:

.29826-- _________

1.11181-- _________

3F-76-1013

Continue to page 15.

Hundredths
41.11
.99

Tenths.
.6

Ten Thousandths
.2983
1.1118

26. If you are NOT having trouble with rounding off, proceed to frame 27. If you are and your trouble is mainly knowing the "places", turn to page 2, frame 7, and review. If you do not understand how to round off, review or raise your hand for assistance.

When you have corrected your trouble, continue to frame 27.

* NO RESPONSE REQUIRED. *

27. Round off each of the following decimals to the indicated place.

To the nearest tenth:

a. .329-- ________

b. .05-- ________

To the nearest hundredth:

c. .10909-- ________

d. 8.3434-- ________

To the nearest thousandth:

e. .2551-- ________

f. 5.9738-- ________

To the nearest ten thousandth:

g. 7.777774-- ________

h. .000891-- ________

To the nearest hundred thousandth:

i. .0980653-- ________

j. 3.000051-- ________

Turn to page 17A for answers.

16A

Very good. The next thing to remember is: Make sure the fraction is in its lowest terms. For example, changing the decimal .5 to a fraction, it first becomes $\frac{5}{10}$. Is this in the lowest terms possible? Of course, the answer is no. In its lowest terms, it would be $\frac{1}{2}$. Always check the fraction and be sure it is in its lowest terms. Try this one now. Change .045 to a fraction.

| If your answer is: | Go to page: |
|---|---|
| $\frac{9}{200}$ | 11A |
| $\frac{45}{1000}$ | 8A |
| $\frac{45}{100}$ | 21B |

---

16B

In order to change a fraction to a decimal, you divide the numerator by the denominator. You did not do this. In the case of $\frac{1}{2}$, the denominator (2) is divided into the numerator (1) like this:

$$\begin{array}{r} .5 \\ 2\overline{)1.0} \\ 1\ 0 \end{array}$$

$\frac{1}{2}$ changed to a decimal is therefore .5 . ALL fractions are changed to decimals in the same manner.

Change $\frac{3}{4}$ to a decimal.

| If your answer is: | Go to page: |
|---|---|
| .750 | 6D |
| .75 | 4A |

17A ANSWERS TO PAGE 15 FRAME 27:

a. .3 b. .1 c. .11 d. 8.34 e. .255 f. 5.974

g. 7.7778 h. .0009 i. .09607 j. 3.00005

You will now learn the last four objectives-- How to ADD, SUBTRACT, MULTIPLY, AND DIVIDE decimals. Continue below.

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

Adding decimals is much the same as simple whole number addition. The difference is that there is a decimal point to keep in mind. The decimals are put in a column and decimal points are under decimal points (see example). The decimal point is brought down to the sum and the addition is carried on just as it is in whole number addition.

EXAMPLE:

$$\begin{array}{r} 6.3 \\ .01 \\ \underline{22.22} \\ 28.53 \end{array}$$

Add these decimals. 33.79 + .97 + 2.2 =

| If your answer is: | Go to page: |
|---|---|
| 36.96 | 19A |
| 3498 | 11B |

17B

Wrong. The number to the right of the division sign is always the divisor.

.064 ÷ 3.2 (3.2 is the divisor, not .064)

Return to page 26 and select the correct answer.

18A

Right. If you want to review before you do the problems below, return to page 9, frame 18, read the rules, and then come back and solve the problems. If you think you are ready now, then change each of the fractions below to decimals.

a. $\frac{4}{5}$

b. $\frac{52}{10}$

c. $\frac{9}{11}$

d. $\frac{13}{10}$

Turn to page 10 to check answers and continue from there.

---

18B

No. Move the decimal point in the dividend the same number of places as you did in the divisor. Example: $3.2\overline{).064}$ because $32.\overline{)0.64}$. Return to page 26 and select the correct answer.

---

18C

You set up your problem incorrectly and had the decimal in the wrong place. This is what you should have set up for your division: $2\overline{)1.00}$ . Return to page 9, frame 18, and determine the correct answer. Then turn to the correct answer page.

19A

Right. The main thing to remember is to keep the decimal points lined up under each other. Now let's subtract decimals. The rules are the same as they are in the subtraction of whole numbers. Just as in the addition of decimals, the decimal points must be lined up under each other. You must also remember that the smaller of the numbers must go under the larger.

Solve this problem: 729.75308 - .0077=

| If your answer is: | Go to page: |
|---|---|
| 729.75231 | 20B |
| 729.74538 | 22 |

19B

ANSWERS TO PAGE 24A: a. 66.42 b. .825 If your answers are not correct, make the corrections and continue below.

Now let's divide decimals. The most important factor is that the divisor must be "made" a whole number before division is started. This is done by moving the decimal in the divisor all the way to the right.

Ex: $.25\overline{)\quad}$ becomes $25.\overline{)\quad}$. Then move the decimal in the dividend the same number of places to the right. Ex: $.25\overline{)1.25}$ becomes $25.\overline{)125.}$ Move the decimal point in the following division problem and solve.

$$3.3\overline{).66}$$

Turn to page 24B.

20A

Right. REMEMBER: The divisor is to the right of the division sign.

Solve these problems and show your work.

a. 4.9 + .007=　　b. 1179 + 13.1=　　c. .02925 + 2.25=

WORK HERE - -

a.　　b.　　c.

Go to page 23B for answers.

20B

Remember when you were told that decimal points must go under decimal points? Well, the error you made was because of the decimal placement. A good way to remember the decimal points is put them on the paper first (in a column) and then put the numbers down. Also remember to put the decimal in the answer DIRECTLY under those in the column. Go back to page 19A and do the problem again.

20C

No. DO NOT ADD an extra zero on the right of any answer. If you need zeros to make your digit count correct, they must go to the left of the answers. For example: .2 x .002 will equal .0004, not .4000. Return to page 23A and select the correct answer.

21A

Your decimal point should have been placed like this:

3.217<br>
x .471<br>
3217<br>
22519<br>
12868<br>
1.515207

If you had it any place else, return to page 22 and read the rules again.

If you did it correctly, do the following problems by placing the decimal points correctly in the product.

a. .0035<br>
x 3.28<br>
280<br>
70<br>
105<br>
11480

b. 22.222<br>
x .11<br>
22222<br>
22222<br>
244442

Turn to page 23A.

21B

There are more than two digits in the decimal .045. Zero IS a digit. That makes three digits in this decimal. You should use the same number of zeros as there are digits and make the denominator 1000. Return to page 16A and select the correct answer.

Right. You are now ready for multiplication. Decimals are multiplied just as whole numbers are, except you have a decimal point to put in the final answer (product). DISREGARD the decimal point in the first two steps. A sample problem is broken into steps to clarify the process.

PROBLEM: .15 x 1.10 =

a. Place the larger number OVER the smaller. Ex.

```
 1.10
x .15
```

b. Multiply just as you do in whole numbers. Ex.

```
 1.10
x .15
  550
 110
 1650
```

c. Count the number of digits to the right of the decimal points in the factors of the problem. Ex. 1.10 and .15 = 4 digits to the right in this case.

d. Count off 4 places FROM THE RIGHT in the PRODUCT, and place a decimal point. Ex. .1650 (product of this problem)

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

Another example: 3.1 x 10.21 (would be set up and solved like this):

```
 10.21
x  3.1
  1021
 3063
 31.651   product
```

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

Place the DECIMAL POINT in the product of this problem:

```
   3.217
x   .471
    3217
  22519
 12868
 1515207
```

Turn to page 21A.

23A

ANSWERS TO PAGE 21A: a. .011480 or .01148 b. 2.44442

Let's try another to make sure that you have the decimal point placement down pat. Solve this one: .55 x .003 =

| If your answer is: | Go to page: |
|---|---|
| .01650 | 20C |
| .00165 | 24A |

---

23B

ANSWERS TO PAGE 20A: a. 700 b. 90 c. .013

Solve these problems: (SHOW ANSWERS.)

a. 289.0038 + .992763 =

b. .3928 - .02867 =

c. .42 x 3.7 =

d. 4.32 ÷ .0036 =

WORK ON SCRATCH PAPER.

Turn to page 25.

24A

Very good. Care must be taken with your arithmetic. It is always a good idea to CHECK your multiplication and addition. This is where most of the errors are made, with a few being made on the placement of the decimal point.

Let's try two more. After completing them, check your arithmetic and decimal placement.

a. $332.1 \times .2 =$

b. $.55 \times 1.5 =$

TURN TO PAGE 19B.

24B

$3.3\overline{).66}$ becomes $\overset{.2}{33.\overline{)6.6}}$ by moving the decimal point one place. When the divisor IS a whole number and the dividend is a decimal, such as $33\overline{)6.4}$, you do not move the decimal point. Simply place the decimal point up in the quotient directly over the decimal point in the dividend; then divide. For example: $275\overline{)3.44}$

Solve this: $26\overline{)7.8}$

The answer to the problem above is: (Circle your answer.)

a. 3

b. .3

c. .03

Turn to page 26.

## ANSWERS TO PAGE 23B

a.
$$\begin{array}{r} 289.003800 \\ + \quad .992763 \\ \hline 289.996563 \end{array}$$

b.
$$\begin{array}{r} .39280 \\ - \; .02867 \\ \hline .36413 \end{array}$$

c.
$$\begin{array}{r} .42 \\ \times \; 3.7 \\ \hline 294 \\ 126 \phantom{0} \\ \hline 1.554 \end{array}$$

d.
$$\begin{array}{r} 1200 \phantom{.} \\ 36 \overline{)43200.} \\ \underline{36} \phantom{000.} \\ 72 \phantom{00.} \\ \underline{72} \phantom{00.} \end{array}$$

If you missed any of these problems, go to the part of the program that teaches that type of problem and read the rules again. THEN correct your error. The pages that teach each function are listed below.

ADDITION (Page 17A)

SUBTRACTION (Page 19A)

MULTIPLICATION (Page 22)

DIVISION (Pages 19B & 26)

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

This completes your lesson in decimals. Working partial numbers is easier when you use decimals rather than fractions, so this lesson is very important.

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

A Self-Test begins on page 27.

$26\overline{)7.8}$ solved is: $26\overline{)\overset{.3}{7.8}}$

If the dividend IS a whole number, Ex: $1.32\overline{)25.}$, add zeros and move the decimal point. Ex: $1.\underset{\curvearrowright}{32}\overline{)25.\underset{\curvearrowright}{00}}\,.$ When the decimal has been moved as appropriate, then place a decimal point in the quotient directly over the point in the dividend, Ex: $2.\underset{\curvearrowright}{5}\overline{).\underset{\curvearrowright}{1}\!\uparrow\!00}$ and solve.

Example: $2.\underset{\curvearrowright}{5}\overline{)\overset{.04}{.\underset{\curvearrowright}{1}\!\uparrow\!00}}$

NOTICE HOW THE QUOTIENT IS .04 AND NOT .4. THIS IS BECAUSE 25 GOES INTO 10 ZERO TIMES, AND INTO 100 FOUR TIMES.

Solve the problem below:

$.064 \div 3.2 =$

Note: ÷ is the sign for division and the number on the right is always the divisor.

| If your answer is: | Go to page: |
|---|---|
| $.\underset{\curvearrowright}{064}\overline{)\overset{50.}{3.\underset{\curvearrowright}{200}.}}$ | 17B |
| $3.\underset{\curvearrowright}{2}\overline{)\overset{.2}{.\underset{\curvearrowright}{0}64}}$ | 18B |
| $3.\underset{\curvearrowright}{2}\overline{)\overset{.02}{.\underset{\curvearrowright}{0}64}}$ | 20A |

## SELF-TEST

## DECIMALS

1. Write, in your own words, the definition of a decimal.

______________________________________________

______________________________________________

2. Match the numerical decimals in Column A with the appropriate word decimals in Column B. Place the letter from Column A in the blank next to the correct word decimal in Column B.

| A | B |
|---|---|
| a. 30.04 | _____ One hundred forty-six |
| b. .379 | _____ Three hundred seventy-nine thousandths |
| c. 1.46 | _____ Thirty and four hundredths |
| d. 90.001 | _____ Ninety-one thousands |
| | _____ Three hundred seventy-nine thousand |
| | _____ One and forty-six hundredths |
| | _____ Thirty-four hundredths |
| | _____ Ninety and one thousandths |

3. Write the numerical form of the following word decimals:

   a. Nine and seventy-five hundredths __________

   b. Twelve and three tenths __________

   c. Seven and one hundred twenty-three thousandths __________

   d. Seventy-three ten thousandths __________

4. Change the fractions below to decimals.

a. $\frac{3}{10} =$ c. $\frac{3}{4} =$

b. $\frac{4}{5} =$ d. $\frac{5}{2} =$

5. Change the decimals below to fractions. REDUCE TO LOWEST TERMS.

a. .25 = c. .105 =

b. .9 = d. .35 =

6. Round off the following decimals as directed.

NEAREST TENTH:

a. .6354 -

NEAREST THOUSANDTH:

c. .05671 -

NEAREST HUNDREDTH:

b. 13.8467 -

NEAREST TEN THOUSANDTH:

d. 1.60006 -

7. Add the following decimals:

a. 9.37 + 15.756 + .76 =

b. 69.333 + .12 + 111.1 =

c. .0055 + 7.12 + 12.367 =

8. Subtract the following decimals:

   a. 13.14 - 2.96 =

   b. .7068 - .077 =

   c. 447.3 - .93 =

9. Multiply the following decimals:

   a. .03 x 10.31 =

   b. .71 x .004 =

   c. 1.51 x .212 =

10. Divide the following decimals:

   a. .08 ÷ .004 =

   b. .00344 ÷ 3.44 =

   c. .04 ÷ .08 =

END

**Answers to the Self-Test are found on page i in the front of the text.**

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Technical Training

3-19

# Basic Mathematics - Fractions

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SHEPPARD AIR FORCE BASE

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**Designed For ATC Course Use**

## ANSWERS TO SELF-TEST

## DECIMALS

1. A decimal is a number that represents a fraction with a denominator that is a power of ten.

2. a. (30.04 thirty and four hundredths)
   b. (.379 three hundred seventy-nine thousandths)
   c. (1.46 one and forty-six hundredths)
   d. (90.001 ninety and one thousandths)

3. a. 9.75 b. 12.3 c. 7.123 d. .0073

4. a. .3 b. .8 c. .75 d. 2.5

5. a. $\frac{1}{4}$ b. $\frac{9}{10}$ c. $\frac{21}{200}$ d. $\frac{7}{20}$

6. a. .6 b. 13.85 c. .057 d. 1.6001

7. a. 25.886 b. 180.553 c. 19.3925

8. a. 10.18 b. .6298 c. 446.37

9. a. .3093 b. .00284 c. .32012

10. a. 20 b. .001 c. .5

## INSTRUCTIONS

## DECIMALS

This is a programmed lesson on DECIMALS. It is not a test as one might think, but an easy way to learn at your own rate of speed.

The two types of programming used in this lesson are:

a. Linear-- Information, in small amounts, will be presented in sequence. You will advance from frame to frame, using a provided cardboard to cover upcoming frames. Do not look ahead at answers. IF YOU MAKE AN ERROR, strike out the incorrect answer and correct it.

b. Branching-- The information given in these frames will be greater and you will be given a list of possible answers. Directions to turn to a page for each answer will be found next to the answers. FOLLOW THESE DIRECTIONS. Circle the answer you think is correct. If you have selected an incorrect answer, put an X through the incorrect response and circle another answer.

READ ALL INFORMATION CAREFULLY. Be sure you understand what is said before you attempt an answer.

If you wish, you may turn back to any part of the program to clarify some vague point.

While working problems in the program, if you are instructed to SHOW ALL WORK, you must work in the program. Otherwise, you may do the work EITHER on scratch paper or in the program.

Continue to page iii

| | |
|---|---|
| | 1. A fraction is a part of a whole. $\frac{3}{4}$ is a fraction and therefore is a part of a ____________. |
| whole | 2. Part of a whole is the definition of a ____________. |
| fraction | 3. The definition of a fraction is stated as: ____________ of a ____________. |
| part<br>whole | 4. Define a fraction. ____________________________________. |
| part of a whole | 5. Fractions have two parts-- a numerator (above the line) and a denominator (below the line).<br>Example: $\frac{3}{8}$ --numerator --denominator<br>In the fraction $\frac{2}{3}$, the number 3 below the line is the ____________ and the number 2 above the line is the ____________. |
| denominator<br>numerator | 6. All fractions have denominators and numerators. In the fractions $\frac{2}{3}$ and $\frac{11}{12}$, the 3 and 12 are ____________ and the 2 and 11 are ____________. |

Continue to page 3

2A

Wrong! 12 x 3 = 36, but you must now do step 2. Add this product (36) to the numerator; retain the denominator to get the improper fraction. Go back to page 11, Frame 29, and select another answer.

---

2B

Nope! You will still have to go to lower terms. You reduced by dividing two into the numerator and denominator but you must now find a number to further reduce $\frac{21}{27}$ and then you'll have it. Return to page 16A, select the other answer, and continue.

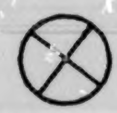
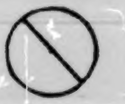
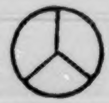
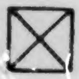
---

2C

$\frac{2}{5}$ is the correct answer.

Now try another problem. $\frac{3}{8} \div \frac{2}{3} =$ ______

| If your answer is: | Go to page: |
|---|---|
| $\frac{1}{4}$ | 18C |
| 4 or $\frac{4}{1}$ | 26B |
| $\frac{9}{16}$ | 28B |

| | |
|---|---|
| denominators<br>numerators | 7. The denominator tells how many equal parts the whole has been divided into. In the fraction $\frac{9}{10}$, the denominator indicates the whole has been divided into _____ equal parts. |
| 10 | 8. Under the figures below, write the number that would be used as the denominator of a fraction.<br>   <br>a. _______ b. _______ c. _______ d. _______ |
| a. 4<br>b. 2<br>c. 3<br>d. 4 | 9. In the fraction below, circle the denominator and explain what it indicates.<br>$\frac{15}{16}$ ______________________________<br>______________________________ |
| 16 denominator<br>Tells (indicates) how many parts the whole has been divided into. | 10. The numerator (number above the line) of a fraction shows "how many parts of the whole are being considered." In the fraction $\frac{2}{3}$, the numerator indicates that _____ parts of the whole are being considered and the denominator indicates that the whole has divided into _____ equal parts. |
| 2<br>3 | 11. In the fraction $\frac{13}{14}$, the number of parts being considered is _____ and the part of the fraction that tells us this is called the ____________. |

Continue to page 5

4A

Wrong! Multiplication and addition are correct but you must place this sum over the denominator of the fraction. Return to page 11, Frame 29, and select another answer.

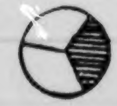
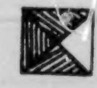
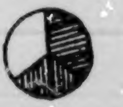
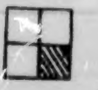
4B

Right! Now try this. Reduce $\frac{14}{56}$ to its lowest term.

| If your answer is: | Go to page: |
|---|---|
| $\frac{1}{4}$ | 6B |
| $\frac{7}{28}$ | 8B |

4C

No! You forgot to obtain the reciprocal of the divisor (invert the divisor), before you multiplied. Go back to page 27, frame 57; review the procedure again, then rework the problem from frame 59 again and select the correct answer.

| | |
|---|---|
| 13<br>numerator | 12. The number of parts being considered is indicated by the ____________ of a fraction. |
| numerator | 13. Under the figures below, write the fractions. The number of parts being considered are shaded.    <br>a. ________ b. ________ c. ________ d. ________ |
| a. $\frac{1}{3}$<br>b. $\frac{3}{4}$<br>c. $\frac{2}{3}$<br>d. $\frac{1}{4}$ | 14. In the fraction below, write what each number is called and what it indicates: $\frac{6}{7}$<br>6 --________________________________<br>________________________________<br>7 --________________________________<br>________________________________ |
| 6 numerator. Indicates how many parts of the whole are being considered<br>7 denominator. Indicates how many equal parts the whole has been divided into. | 15. There are three types of common fractions--proper, improper, and mixed numbers. The three types of common fractions are mixed numbers, ____________ and ____________ fractions. |
| proper<br>improper<br>(either order) | 16. The difference between proper and improper fractions is the size of the numerator. The numerator of an improper fraction is always the same as or larger than the denominator; therefore, in a proper fraction, the numerator is ____________ than the denominator. |

Continue to page 7

6A

Correct. Now change $15\frac{1}{5}$ to an improper fraction.

| If your answer is: | Go to page: |
|---|---|
| $\frac{76}{5}$ | 8A |
| $\frac{75}{5}$ | 10A |

6B

Good! You might have started with dividing by two (2) and doing several steps, but 14 divides into 14 and 56 evenly. To reduce an improper fraction such as $\frac{8}{4}$ or $\frac{9}{5}$, you simply divide the denominator into the numerator. Reduce $\frac{9}{5}$ to its lowest terms.

| If your answer is: | Go to page: |
|---|---|
| $\frac{9}{5}$ | 10B |
| $1\frac{4}{5}$ | 12B |

| | |
|---|---|
| smaller (less than) | 17. $\frac{7}{8}$ is a proper fraction because the ____________ is ____________ than the denominator. |
| numerator<br>smaller (less) | 18. $\frac{8}{7}$ and $\frac{8}{8}$ are improper fractions because the ____________ are ____________ than the denominators. |
| numerators<br>are same as or greater (are the same as or larger) | 19. In the list below, place a "P" by the proper fractions and "I" by the improper fractions.<br>a. $\frac{12}{17}$ c. $\frac{4}{5}$<br>b. $\frac{9}{7}$ d. $\frac{12}{12}$ |
| a. P c. P<br>b. I d. I | 20. A mixed number is a whole number combined with a proper fraction. $3\frac{5}{6}$ is a whole number (3) and a proper fraction $\frac{(5)}{(6)}$; therefore, $3\frac{5}{6}$ is a ____________. |
| mixed number | 21. To review definitions, match the following types of fractions with the correct statement or statements by writing the letter of the statement by the number of the fraction. All letters are to be used.<br>1. Proper fraction<br>2. Mixed number<br>3. Improper fraction<br>A. Numerator greater than the denominator<br>B. Numerator less than the denominator<br>C. Whole number and a proper fraction<br>D. Numerator equal to denominator |

Continue to page 9

8A

Right! $\frac{76}{5}$ is correct. You can check your answers by changing the improper fraction back to the mixed number. Change 7¼ to an improper fraction and check your answer.

$$7\frac{1}{4} = \underset{\text{(improper fraction)}}{\underline{\qquad\qquad\qquad}} = \underset{\text{(mixed number)}}{\underline{\qquad\qquad\qquad}}$$

Go to page 13, Frame 30, to check answer and continue from there.

8B

You reduced—but not to the lowest terms. Return to page 4B and find the number that will reduce the $\frac{7}{28}$ and then you'll have the correct answer that will allow you to continue.

| | |
|---|---|
| B. 1.<br>C. 2.<br>D,A 3. | 22. In the list below, place a "P" by the proper fractions, an "I" by the improper fractions, and a "M" by the mixed numbers.<br>a. $3\frac{1}{2}$<br>b. $\frac{9}{5}$<br>c. $12\frac{2}{3}$<br>d. $\frac{3}{4}$<br>e. $\frac{22}{29}$<br>f. $\frac{7}{7}$<br>g. $\frac{79}{75}$ |
| a. M e. P<br>b. I f. I<br>c. M g. I<br>d. P | 23. An improper fraction can be changed to a mixed number by dividing the denominator into the numerator. The fraction $\frac{21}{10}$ can be changed to a mixed number by dividing the numerator ______ (number) by ______ (number) the denominator. |
| 21<br>10 | 24. To change the improper fraction $\frac{21}{10}$ to a mixed number, follow two steps: (1) Divide the numerator by the denominator to get the whole number:<br>$10\overset{2}{\overline{)21}}$ the whole number<br>$\underline{20}$<br>$1$ the remainder<br>(2) Place the remainder over the denominator to get the proper fraction: $\frac{1}{10}$ the proper fraction.<br>Then $\frac{21}{10}$ ______ (mixed number) |
| $2\frac{1}{10}$ | 25. Now change the improper fraction $\frac{26}{5}$ to a mixed number. Show your work. $\overline{)\quad}$<br>\______ (mixed number) |

Continue to page 11

10A

Wrong! You forgot to add the numerator to the product of the whole number times the denominator. If you now see your error, go back to page 6A and select the other answer and follow directions. If you need the rule again, return to page 11, Frame 28, and start again from there.

10B

No... To reduce an improper fraction, you simply change it to a whole number or to a whole number and a fraction (mixed number) by dividing the numerator by the denominator. Now go back to page 6B and reduce properly.

10C

Negative. You have simply added numerators, retained highest denominator, and reduced. You must change to equivalent fractions. Re-read rule on page 17, Frame 40, and rework problem from page 19, Frame 43, again.

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| | |
|---|---|
| $\begin{array}{r} 5 \\ 5\overline{)26} \\ \underline{25} \\ 1 \end{array}$<br>$5\frac{1}{5}$<br>(mixed number) | 26. Try another. Change $\frac{54}{11}$ to a mixed number.<br>$\overline{)\quad\quad}$ = ________. |
| $4\frac{10}{11}$ --if you missed this one, re-read and re-work Frames 22 thru 26, then continue. | 27. An improper fraction can be changed to a mixed number. So can a mixed number be changed to an improper fraction. Therefore, an improper fraction is interchangeable with a ________ number. |
| mixed | 28. Changing mixed numbers to improper fractions requires three steps: Example: Change $4\frac{3}{5}$ to an improper fraction.<br>Step<br>(1) Multiply the whole number by the denominator of the fraction. $4 \times 5 = 20$<br>(2) Add the product to the numerator. $20 + 3 = 23$.<br>(3) Place the sum over the denominator of the fraction.<br>Then $4\frac{3}{5}$ = ________ (improper fraction) |
| $\frac{23}{5}$ | 29. Change $12\frac{2}{3}$ to an improper fraction.<br>If your answer is: Go to page:<br>$\frac{36}{3}$ 2A<br>$\frac{38}{2}$ 4A<br>$\frac{38}{3}$ 6A |

12A

No! $\frac{2}{4}$ can be reduced to $\frac{1}{2}$ by dividing two (2) into both the numerator and denominator. Remember the rule, a fraction is in its lowest terms only when the number one (1) is the only number that divides evenly into both the numerator and denominator. Return to page 13, Frame 31, and select the correct answer.

12B

1 $\frac{4}{5}$ is correct. If we ask you to reduce the fraction $\frac{8}{4}$, would you answer 2? You would have been correct there, too. Now turn to top of page 15, Frame 32, and continue the program.

12C

No. You've added numerators but have not changed fractions to equivalent fractions. Read rule again on page 17, Frame 40, then rework problem on page 19, Frame 43. Select another answer.

If you came to this page directly from the previous page, you have not followed the directions given in the previous frame. From this point (unless otherwise directed) in the lesson, you will proceed by the scrambled method. Do Not read the frames in sequence, but after selecting an answer, refer to the proper page or frame as directed. Return to page 11, Frame 29, check your answer, and refer to the page as directed.

$7\frac{1}{4} = \frac{29}{4}$

$\frac{29}{4} = 7\frac{1}{4}$

30. Change each of the following improper fractions to mixed numbers and the mixed numbers to improper fractions:

a. $1\frac{4}{9}$
c. $10\frac{11}{12}$
b. $\frac{21}{8}$
d. $\frac{49}{3}$

a. $\frac{13}{9}$
b. $2\frac{5}{8}$
c. $\frac{131}{12}$
d. $16\frac{1}{3}$

31. A fraction is in its lowest terms when the number one (1) is the only number that divides evenly into both the numerator and denominator. (NOTE: Dividing both the numerator and denominator by the same number does not change the value of the fraction) Select the fraction below that is in its lowest terms.

| If your answer is: | Go to page: |
|---|---|
| $\frac{2}{4}$ | 12A |
| $\frac{6}{9}$ | 14A |
| $\frac{3}{7}$ | 16A |

14A

Wrong! $\frac{6}{9}$ can be further reduced. Three (3) is the largest number that divides evenly into both the numerator (6) and the denominator (9). $\frac{6}{9}$, then, reduced to lowest possible terms, is $\frac{2}{3}$. Now return to page 13, Frame 31, and select the correct answer.

---

14B

Right! $1\frac{1}{4}$ is the correct answer. Try another, reduce to lowest terms.

Add $\frac{1}{2} + \frac{1}{2} + \frac{4}{5} + \frac{3}{20} =$ ____________

| If your answer is: | Go to page: |
|---|---|
| $1\frac{9}{10}$ | 18B |
| $1\frac{19}{20}$ | 20B |

| | |
|---|---|
| You came from page 12B. | 32. Reduce each of the following fractions to lowest terms:<br>a. $\frac{12}{4} =$ c. $\frac{64}{72} =$<br>b. $\frac{21}{49} =$ d. $\frac{17}{51} =$ |
| a. 3 or $\frac{3}{1}$<br>b. $\frac{3}{7}$<br>c. $\frac{8}{9}$<br>d. $\frac{1}{3}$ | 33. To add or subtract fractions, they must be like fractions. Like fractions have the same number for a denominator. $\frac{7}{12} + \frac{5}{12}$ or $\frac{7}{12} - \frac{5}{12}$ are like fractions because they have the same number for a ____________. |
| denominator | 34. Fractions must have like (common) denominators before you can ____________ or ____________ them. |
| add<br>subtract<br>(any order) | 35. When fractions have common denominators, you add or subtract numerators and retain the common denominator.<br>Example: $\frac{7}{12} + \frac{5}{12} = \frac{12}{12}$ reduced = 1<br>Then $\frac{7}{12} - \frac{5}{12} =$ ____________ reduced = __________. |
| $\frac{2}{12}$<br>$\frac{1}{6}$ | 36. Before fractions with unlike denominators can be added or subtracted, they must be changed to their lowest common denominator (LCD). LCD is the lowest number that is divisible by each denominator. Example: $\frac{2}{5} + \frac{1}{20}$ or $\frac{2}{5} - \frac{1}{20}$ The lowest number divisible by each denominator is 20; therefore, 20 is the ____________. |

Continue to page 17

16A

$\frac{3}{7}$ is correct. One (1) is the only number that divides evenly into both 3 and 7.

Let's try a larger fraction. Reduce $\frac{42}{54}$ to its lowest terms.

| If your answer is: | Go to page: |
|---|---|
| $\frac{21}{27}$ | 2B |
| $\frac{7}{9}$ | 4B |

16B

No. Not quite. Your addition is correct but you must have overlooked the "reduce answers to lowest terms." Go back to page 19, Frame 43, reduce, and pick the correct answer.

16C

$\frac{6}{15}$ is wrong. You borrowed one (1) from 16, which gave you the fraction $\frac{15}{15}$, but now you must add $\frac{15}{15} + \frac{8}{15}$, then do your subtraction. Return to page 20A, rework the problem, and select another answer.

| | |
|---|---|
| least or lowest common denominator or (LCD) | 37. Again, the lowest number divisible by each denominator of fractions to be added or subtracted is called the ______________. |
| LCD | 38. Determine the lowest common denominator (LCD) for these fractions: $\frac{1}{2} + \frac{1}{4}$, the LCD is ______.<br>$\frac{2}{7} - \frac{1}{42}$, the LCD is ______. |
| 4<br>42 | 39. Find the LCD for the fractions below:<br>a. $\frac{5}{8} + \frac{1}{16} + \frac{1}{4}$, the LCD is ______.<br>b. $\frac{4}{7} - \frac{1}{49}$, the LCD is ______. |
| a. 16<br>b. 49 | 40. After the LCD has been determined, change all fractions to equivalent fractions of the same denominator; then add or subtract. Example: $\frac{2}{7} + \frac{1}{42}$, the LCD is 42. To change $\frac{2}{7}$ to LCD 42: Divide 7 into 42; the quotient is 6. Multiply 6 by the numerator 2 and place the product (12) over the LCD. $\frac{2}{7} = \frac{12}{42}$. Now we can add. $\frac{12}{42} + \frac{1}{42} = \frac{13}{42}$ reduced is $\frac{13}{42}$.<br>Change the fractions below so they have the same LCD.<br>a. $\frac{1}{3} + \frac{5}{6} \div \frac{1}{12} =$ ______ + ______ ÷ ______<br>b. $\frac{4}{5} - \frac{1}{3} =$ ______ - ______ |

Continue to page 19

18A

You have the correct fraction but made a mistake in the addition of whole numbers. Now return to page 22B and work the problem again. Do not just pick the other answer without first re-working the problem to find your error.

18B

Incorrect. You've made a mistake someplace in changing fractions to equivalent fractions of the same denominator. Return to page 17, Frame 40, re-read the rule, then go back to page 14B and choose the other answer.

18C

$\frac{1}{4}$ is wrong. You did not obtain the reciprocal of the divisor. $\frac{2}{3}$ inverted is $\frac{3}{2}$ and the reciprocal of $\frac{2}{3}$ is also $\frac{3}{2}$. Go back to page 2C, rework the problem, and select the correct answer.

IV- 76-207

| | |
|---|---|
| a. $\frac{4}{12} + \frac{10}{12} + \frac{1}{12}$<br>b. $\frac{12}{15} - \frac{5}{15}$ | 41. Find the LCD and change the fractions below to equivalent fractions.<br>a. $\frac{1}{9} + \frac{1}{81} + \frac{2}{3} =$ ______ + ______ + ______<br>b. $\frac{4}{5} - \frac{5}{8} =$ ______ - ______ |
| a. $\frac{9}{81} + \frac{1}{81} + \frac{54}{81}$<br>b. $\frac{32}{40} - \frac{25}{40}$ | 42. The rule again for adding and subtracting fractions. (1) Change fractions to common denominators. (2) Add or subtract numerators. (3) Keep common denominator. (4) Reduce answers to lowest terms. At your left and below are the LCD problems from the last frame. Complete the problems.<br>a. $\frac{9}{81} + \frac{1}{81} + \frac{54}{81} =$ ______ reduced ______<br>b. $\frac{32}{40} - \frac{25}{40} =$ ______ reduced ______ |
| $\frac{64}{81}$ reduced is $\frac{64}{81}$<br>$\frac{7}{40}$ reduced is $\frac{7}{40}$ | 43. Does it all come back to you now? Solve this problem and reduce answer to lowest terms.<br>$\frac{1}{28} + \frac{6}{7} + \frac{5}{14} =$ ______<br>If your answer is: Go to page:<br>$1\frac{1}{4}$ 14B<br>$1\frac{7}{28}$ 16B<br>$\frac{12}{28}$ 12C<br>$\frac{2}{7}$ 10C |
| You came from page 24A.<br>a. $1\frac{2}{7}$<br>b. $1\frac{1}{8}$<br>c. $13\frac{9}{16}$<br>d. $1\frac{3}{4}$ | 44. When multiplying two or more fractions, multiply numerators of the fractions to obtain numerator of the product. To obtain the numerator of the product in the problem $\frac{2}{3} \times \frac{2}{3}$, multiply ______ (number) times ______ (number). |

Continue to page 21

20A

Very good. Work the following problem by subtracting mixed numbers. Reduce answer to lowest term. $16\frac{8}{15} - 15\frac{3}{5} =$ ______

| If your answer is: | Go to page: |
|---|---|
| $1\frac{14}{15}$ | 22A |
| $\frac{14}{15}$ | 24A |
| $\frac{6}{15}$ | 16C |
| can't be solved | 26C |

20B

Good. $1\frac{19}{20}$ is correct. Now try one on subtraction and reduce answer to lowest terms. $\frac{4}{13} - \frac{3}{39} =$ ______.

| If your answer is: | Go to page: |
|---|---|
| $\frac{3}{13}$ | 22B |
| $\frac{3}{39}$ | 31A |

20C

No. $6\frac{29}{36}$ is incorrect. Again you forgot to invert the divisor. The divisor $1\frac{1}{6}$ is changed to $\frac{7}{6}$ and inverted is $\frac{6}{7}$. Now go back to page 28B and select another answer.

| | |
|---|---|
| 2<br>2 | 45. Like the numerator, the denominator of the product is obtained by multiplying the denominators of the fractions. In the problem $\frac{2}{3} \times \frac{4}{5}$ , the numerator of the product is obtained by multiplying __________ times __________ and the denominator is obtained by multiplying __________ times __________. |
| 2 x 4<br>3 x 5 | 46. The rule, then, for multiplying fractions is: "Multiply numerators of the fractions to obtain the __________ of the product and multiply the denominators to obtain the __________ of the product." Solve this problem:<br>$\frac{2}{3} \times \frac{2}{5}$ = __________. |
| numerator<br>denominator<br>$\frac{4}{15}$ | 47. The word "of" is sometimes used in place of the multiplication sign "x". $\frac{2}{3}$ of 15 = 10 can be written as $\frac{2}{3} \times \frac{15}{1} = \frac{30}{3} = 10$. Solve this problem and reduce: $\frac{5}{8}$ of 40 = ______ reduced ______. |
| $\frac{200}{8}$<br>reduced = 25 | 48. If the problem contains more than two fractions, multiply all the numerators and multiply all the denominators. Example:<br>$\frac{2}{5} \times \frac{1}{3} \times \frac{2}{3} \times \frac{1}{4} = \frac{4}{180}$ reduced $\frac{1}{45}$<br>Solve this problem:<br>$\frac{3}{5} \times \frac{4}{7} \times \frac{1}{2}$ = __________ reduced = __________ |

Continue to page 23

76-297

22A

You've forgotten the rule on borrowing.

$$\begin{array}{rcccc} 16\frac{8}{15} & = & 16\frac{8}{15} & = & 15\frac{23}{15} \\ -\,15\frac{3}{5} & = & 15\frac{9}{15} & = & 15\frac{9}{15} \\ \hline \end{array}$$

You cannot subtract $\frac{9}{15}$ from $\frac{8}{15}$, so you have to borrow a whole number (1). $1 = \frac{15}{15}$, which you now add to the $\frac{8}{15}$. Don't forget now that you borrowed a whole number from 16. Go back to page 20A. Re-work the problem and select the correct answer.

22B

Good. Now for the rule for adding and subtracting mixed numbers: 1. Change fractions to like fractions (LCD). 2. Add/subtract the fractions. 3. Add/subtract the whole numbers. 4. Reduce answers to lowest terms. Example: $1\frac{1}{3} + 3\frac{11}{12}$ and $7\frac{1}{2} - 4\frac{1}{5}$.

$$\begin{array}{rcl} 1\frac{1}{3} & = & 1\frac{4}{12} \\ +\,3\frac{11}{12} & = & 3\frac{11}{12} \\ \hline & & 4\frac{15}{12} = 4 + 1\frac{3}{12} = 5\frac{1}{4} \end{array} \qquad \begin{array}{rcl} 7\frac{1}{2} & = & 7\frac{5}{10} \\ -\,4\frac{1}{5} & = & 4\frac{2}{10} \\ \hline & & 3\frac{3}{10} \end{array}$$

Now add these fractions: $7\frac{1}{9} + 6\frac{5}{18} + \frac{1}{6} =$ ______.

| If your answer is: | Go to page: |
|---|---|
| $14\frac{5}{9}$ | 18A |
| $13\frac{5}{9}$ | 20A |

| | |
|---|---|
| $\frac{12}{70}$<br>reduced = $\frac{6}{35}$ | 49. "Cancellation" is a "short cut" used in multiplying fractions. The short cut in multiplying fractions is called ____________. |
| cancellation | 50. Cancellation is much the same as reducing. The first step is to select a numerator and denominator that can be divided evenly by the same number. The problem $\frac{5}{10} \times \frac{2}{5} \times \frac{4}{10}$ can be reduced to: $\frac{\overset{1}{\cancel{5}}}{\underset{5}{\cancel{10}}} \times \frac{\overset{1}{\cancel{2}}}{\underset{1}{\cancel{5}}} \times \frac{\overset{2}{\cancel{4}}}{\underset{5}{\cancel{10}}}$. The next step is to multiply the numerators and the denominators $\frac{1}{5} \times \frac{1}{1} \times \frac{2}{5} = \frac{2}{25}$ reduced is $\frac{2}{25}$. Solve the problem below by cancellation. Show work.<br>$\frac{5}{8} \times \frac{4}{7} \times \frac{1}{5} =$ _____. |
| $\frac{\overset{1}{\cancel{5}}}{\underset{2}{\cancel{8}}} \times \frac{\overset{1}{\cancel{4}}}{7} \times \frac{1}{\underset{1}{\cancel{5}}} = \frac{1}{14}$ | 51. When you use the cancellation method, the basic principle is: Dividing both the numerator and the denominator by the same number does not change the value of a fraction. The value of a fraction is not changed when the ____________ and the ____________ are ____________ by the same number. |
| numerator<br>denominator (either order)<br>divided | 52. In the problem $\frac{2}{15} \times \frac{3}{3}$, the 2 and 8 can be cancelled by dividing each by ____________ and the 3 and 15 cancelled by dividing each by ____________. The answer to the problem, then, is ____________. |

Continue to page 25

24A

Very good. The idea here was to see if you remember how to borrow. Solve the addition and subtraction problems below. Answers must be in lowest terms.

a. $\frac{1}{21} + \frac{4}{7} + \frac{2}{3} =$

b. $3\frac{3}{8} - 2\frac{1}{4} =$

c. $11\frac{1}{8} + 1\frac{3}{16} + \frac{1}{2} + \frac{3}{4} =$

d. $14\frac{1}{6} - 12\frac{5}{12} =$

Go to page 19, Frame 44, to check answers and continue from there.

24B

5 is the correct answer. Try one more.

$$5\frac{4}{7} + 3 =$$

| If your answer is: | Go to page: |
|---|---|
| $1\frac{6}{7}$ | 29B |
| $16\frac{5}{7}$ | 30A |
| $\frac{13}{7}$ | 28A |

| | |
|---|---|
| 2<br>3<br>$\frac{1}{20}$ | 53. In the problem $\frac{10}{13} \times \frac{26}{50} \times \frac{7}{21}$, the 10 and 50 are cancelled by dividing each by ________; the 13 and 26 are cancelled by dividing each by ________; and $\frac{7}{21}$ can be reduced to ______.<br>Now solve the problem, showing your cancellation.<br>$\frac{10}{13} \times \frac{26}{50} \times \frac{7}{21} =$ ________. |
| 10; 13; $\frac{1}{3}$<br>$\frac{\overset{1}{\cancel{10}}}{\underset{1}{\cancel{13}}} \times \frac{\overset{2}{\cancel{26}}}{\underset{5}{\cancel{50}}} \times \frac{\overset{1}{\cancel{7}}}{\underset{3}{\cancel{21}}} =$<br>ans. $\frac{2}{15}$ | 54. Solve the following problems, using cancellation where applicable. Reduce answers to lowest terms.<br>a. $\frac{2}{5} \times \frac{3}{10} \times \frac{7}{9} =$<br>b. $\frac{12}{16} \times \frac{8}{24} \times \frac{8}{10} =$ |
| a. $\frac{7}{75}$<br>b. $\frac{1}{5}$ | 55. In order to multiply fractions and mixed numbers, the mixed numbers must be changed to improper fractions.<br>Example: $2\frac{1}{2} \times \frac{3}{8} \times 1\frac{1}{3}$ will be changed to<br>$\frac{5}{2} \times \frac{\overset{1}{\cancel{3}}}{\underset{2}{\cancel{8}}} \times \frac{\overset{1}{\cancel{4}}}{\underset{1}{\cancel{3}}} = \frac{5}{4}$ reduced is $1\frac{1}{4}$<br>Solve the following problems, using cancellation where applicable, and reduce answers to lowest terms:<br>a. $3\frac{1}{3} \times 5\frac{1}{2} \times \frac{9}{10} =$<br>b. $4\frac{1}{2} \times 3\frac{1}{3} \times 2\frac{2}{8} =$<br>c. $\frac{3}{4}$ of 80 = |

Continue to page 27

26A

Not quite. $\frac{35}{7}$ is an improper fraction and for the answer to be completely correct (lowest terms), you must now change your answer to a mixed number. Return to page 28B, recheck your work, and reduce answer to lowest terms.

---

26B

4 or $\frac{4}{1}$ is incorrect. You obtained the reciprocal of the dividend. You're to obtain the reciprocal of the divisor and then proceed as in multiplication. Now go to page 2C, rework the problem, and select the correct answer.

---

26C

You've forgotten the rule on borrowing. True, you can't subtract $15\frac{9}{15}$ from $16\frac{8}{15}$ unless you borrow. Why not take one (1) from 16 and add the fraction $\frac{15}{15}$ to $\frac{8}{15}$? Now you can subtract, but don't forget the one (1) you borrowed. Go back to page 20A, rework the problem, and select another answer.

| | |
|---|---|
| a. $16\frac{1}{2}$<br>b. $33\frac{3}{4}$<br>c. 60 | 56. Solve the problems below, cancelling where applicable, and reduce answers to lowest terms.<br>a. $\frac{3}{5}$ of $2\frac{5}{8} =$<br>b. $3\frac{1}{2} \times 2\frac{1}{4} \times \frac{2}{3} =$<br>c. $\frac{1}{6}$ of $24 =$<br>d. $2\frac{1}{8} \times 3\frac{3}{4} \times 1\frac{1}{3} =$ |
| a. $1\frac{23}{40}$<br>b. $5\frac{1}{4}$<br>c. 4<br>d. $10\frac{5}{8}$ | 57. Dividing common fractions requires two steps:<br>Example: $\frac{2}{7} \div \frac{1}{3} =$<br>Dividend Divisor<br>(1) Obtain reciprocal of divisor (invert divisor) — — $\frac{3}{1}$.<br>(2) Multiply the dividend by the reciprocal of the divisor — — $\frac{2}{7} \times \frac{3}{1} = \frac{6}{7}$.<br>Then $\frac{2}{7} \div \frac{1}{3} =$ ____. |
| $\frac{6}{7}$ | 58. Fill in the steps to find $\frac{5}{9} \div \frac{3}{4}$.<br>(1) Obtain reciprocal of divisor (invert the divisor). ___<br>(2) Multiply the dividend by the reciprocal of the divisor. ___<br>Then $\frac{5}{9} \div \frac{3}{4} =$ ____. |
| $\frac{4}{3}$<br>$\frac{5}{9} \times \frac{4}{3}$<br>$\frac{20}{27}$ | 59. Solve this problem: $\frac{3}{10} \div \frac{3}{4}$<br>If your answer is: Go to page:<br>$\frac{2}{5}$ 2C<br>$\frac{9}{40}$ 4C<br>$\frac{12}{30}$ 29A |

28A

$\frac{13}{7}$ is unacceptable, because answers will always be reduced to their lowest terms. Return to page 24B and select the correct answer that is in its lowest terms.

---

28B

$\frac{9}{16}$ is correct.

Dividing with mixed numbers requires three steps: (1) Change the mixed number or mixed numbers to improper fractions. (2) Obtain the reciprocal of the divisor (invert divisor). (3) multiply the dividend by the reciprocal of the divisor.

Try this problem: $5\frac{5}{6} \div 1\frac{1}{6} =$

| If your answer is: | Go to page: |
|---|---|
| $5$ | 24B |
| $6\frac{29}{36}$ | 20C |
| $\frac{35}{7}$ | 26A |

29A

Not quite right. You must not have cancelled the 3's after obtaining the reciprocal of the divisor and you haven't reduced to the lowest terms. Go back to page 27, frame 59, and correct your mistake. Then select the correct answer.

---

29B

$1\frac{6}{7}$ is correct. Divide the following fractions and reduce answers to lowest terms:

a. $\frac{5}{8} \div \frac{3}{4} =$

b. $22 \div 6\frac{7}{8} =$

c. $2\frac{1}{6} \div 4\frac{1}{2} =$

d. $\frac{8}{21} \div 3\frac{3}{7} =$

GO TO PAGE 30B TO CHECK YOUR ANSWERS.

30A

No! Does it sound reasonable that 3 is contained in $5\frac{4}{7}$ - - - 16 and $\frac{5}{7}$ times ? You forgot to obtain the reciprocal of the divisor before you multiplied. Go back to page 24B, invert the divisor, multiply, and then select the correct answer.

30B

Answers from page 29B: a. $\frac{5}{6}$ b. $3\frac{1}{5}$ c. $\frac{13}{27}$ d. $\frac{1}{9}$

If you had any answers other than those above, you must rework the problem(s on page 29B. When you've gotten all correct, solve these problems:

a. $5\frac{2}{3} \div 9\frac{5}{9} =$

b. $5\frac{2}{5} \times 2\frac{1}{4} \times 4\frac{2}{3} =$

c. $21\frac{1}{16} + 9\frac{3}{8} + 8\frac{1}{2} + \frac{3}{4} =$

d. $3\frac{3}{16} - 1\frac{3}{4} =$

GO TO PAGE 32A TO CHECK YOUR ANSWERS.

31A

Never! The only way you could have arrived at this answer was to have reduced the numerator and not the denominator. Return to page 20B, work the problem again, and select the correct answer.

32A

Answers from page 30B:

a. $\frac{51}{86}$ b. $56\frac{7}{10}$ c. $39\frac{11}{16}$ d. $1\frac{7}{16}$

If you missed any problem, you must rework and recheck. After all problems are correct, read the rules again that are on the pages listed below and then go to page 32B.

| Problem: | Go to page: |
|---|---|
| a. (division) | 28B |
| b. (multiplication) | 25, Frame 55 |
| c. (addition) | 22B |
| d. (subtraction and borrowing) | 22A |

After you've read the rules again, go to page 32B.

32B

You have completed the Programmed Lesson on fractions. For some, the program was just a review; for others, it has been a process of learning.

A SELF-TEST ON FRACTIONS COMMENCES ON PAGE 33.

SP 76-297

## SELF-TEST ON FRACTIONS

1. Write the definition of a fraction.

2. Identify the two parts of the fraction $\frac{7}{8}$ and explain what each part shows.

7--

8--

3. Identify the proper fractions, the improper fractions, and the mixed numbers in the following list by placing a "P" by the proper fractions, an "I" by the improper fractions, and a "M" by the mixed number.

a. $\frac{15}{16}$

b. $\frac{19}{17}$

c. $2\frac{4}{5}$

d. $\frac{9}{7}$

e. $77\frac{2}{3}$

f. $\frac{300}{299}$

g. $\frac{10}{11}$

h. $\frac{7}{12}$

i. $6\frac{3}{7}$

j. $\frac{5}{6}$

4. Change the mixed numbers to improper fractions and the improper fractions to mixed numbers.

a. $3\frac{2}{3}$

b. $\frac{11}{10}$

c. $12\frac{4}{5}$

d. $\frac{19}{15}$

e. $7\frac{7}{8}$

Continue to page 34

5. Reduce the following fractions to their lowest terms:

a. $\frac{18}{81}$

b. $\frac{9}{12}$

c. $\frac{21}{63}$

d. $\frac{3}{7}$

e. $\frac{14}{21}$

f. $\frac{16}{64}$

6. Solve the following ADDITION and SUBTRACTION problems. Reduce answers to lowest terms.

a. $\frac{1}{2} + \frac{1}{2} =$

b. $\frac{5}{7} - \frac{2}{3} =$

c. $\frac{3}{8} + \frac{3}{4} =$

d. $2\frac{3}{8} - 1\frac{5}{8} =$

e. $6\frac{7}{10} - 4\frac{4}{5} =$

f. $11\frac{3}{4} + 19\frac{5}{8} + 9\frac{1}{2} + \frac{3}{16} =$

7. Multiply the following fractions, cancelling where applicable. Reduce answers to lowest terms.

a. $\frac{1}{2} \times \frac{2}{4} \times \frac{2}{3} =$

b. $4\frac{2}{3} \times 5\frac{1}{4} \times 2\frac{2}{3} =$

c. $\frac{3}{4} \times 5\frac{1}{2} =$

d. $\frac{1}{8}$ of $16 =$

8. Divide the following fractions, cancelling where applicable. Reduce answers to lowest terms.

a. $\frac{7}{8} \div \frac{7}{16} =$

b. $15 \div 4\frac{1}{5} =$

c. $4\frac{2}{3} \div 12\frac{4}{9} =$

d. $\frac{4}{5} \div 2\frac{7}{15} =$

Answers to Self-Test on
page i in front of text

STUDY GUIDE 3ABR55233-II-1 thru II-9

3-19

Department of Civil Engineering Training

Masonry Specialist

# RIGID CONCRETE STRUCTURES

March 1975

SHEPPARD AIR FORCE BASE

Designed For ATC Course Use

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This supersedes SG 3ABR55233-II-1 thru II-9, 5 July 1973
Previous editions may be used until stock is exhausted.

Department of Civil Engineering Training
Sheppard Air Force Base, Texas

SG 3ABR55233-II-1
3 March 1975

# CONCRETE MIXTURES

## OBJECTIVE

To help you in learning the properties of cement and concrete mixtures and the importance of good materials and proper proportioning to obtain a finished product of the highest quality.

## INTRODUCTION

Concrete is one of the most useful building materials ever developed by man. It is strong, long-lasting, fairly cheap to use, and easy to handle. Huge dams, bridges, skyscrapers, roads and runways are built of concrete.

Each of us has an idea of what cement is. We also have an idea of what concrete is. But do we know what the properties of cement are? Also, do we know how to mix quality concrete to obtain a finished product of the highest quality that will present the least amount of maintenance.

This study guide covers the following main topics:

CONCRETE INGREDIENTS

WATER-CEMENT RATIO

CONCRETE ADDITIVES

FACTORS AFFECTING CONCRETE STRENGTH

INGREDIENTS OF STANDARD MIXES

METHODS OF PREPARING A STANDARD CONCRETE MIX

SLUMP TEST

SAFETY PRECAUTIONS

## INFORMATION

### CONCRETE INGREDIENTS

Concrete is a mixture of Portland cement and water mixed to a paste that coats and binds the fine and coarse (aggregates) materials together, in a rocklike mass.

#### Cement

What is cement? A definition of cement is a material that binds two or more things together.

What is Portland cement? We know it is the material used in mixing concrete. In 1824, Joseph Aspdin took out a patent in Portland, England for the manufacture of an improved cement. To this he gave the name Portland cement. In 1875, D. O. Saylor, here in the United States, and after many experiments and trials, produced true Portland cement, as we know it today.

TYPES OF CEMENT. Portland cement (manufactured in the United States) derives its name from Portland, England, where the process for making it originated. This cement is available in five different types, ranging from Type I to Type V. Cement is available by the barrel, weighing 376 pounds and is equal to 4 sacks in volume, one sack weighing 94 pounds.

| | |
|---|---|
| Type I | Normal Portland cement is most generally used for pavements, sidewalks, buildings, bridges, and masonry units. When used for pavements, a total of 28 days must elapse before it is opened to traffic. |
| Type II | Modified Portland cement generates less heat during hydration than Type I and is used for structures of considerable size. |
| Type III | High-early-strength Portland cement is used when high strength is desired at a very early period. In cold weather construction the time required for protection against freezing is reduced. Type III cement is manufactured so it attains normal 3-day strength in 1 day, 7-day strength in 3 days, and 28-day strength in 7 days. This is illustrated in figure 1. The evolution of heat during hydration is also accelerated. Normally, this cement is not used in large-scale operations since it is more expensive than ordinary Portland cement. |
| Type IV | Low-heat Portland cement generates a relatively small amount of heat while hydrating. It is intended for use in large masses of concrete such as large dams. |
| Type V | Sulphate-resistant Portland cement is intended for use where the concrete will be in contact with soil or water of high alkali content. |

STORAGE OF CEMENT. The method by which cement is stored can be an important factor in maintaining concrete of consistent mixtures. Therefore, store the material according to specifications. Sacked cement which is to be stored for a long period of time should be placed in a near airtight warehouse or shed. The floor of the shed should be above the ground and all cracks in the wall sealed. Sacks should be stacked close together to reduce air circulation. The sacks of cement should be stored on a raised floor away from the walls. A suitable temporary storage shed is shown in figure 1. Note that the tarpaulin extends over the edge of the platform to prevent rain from collecting on the platform and

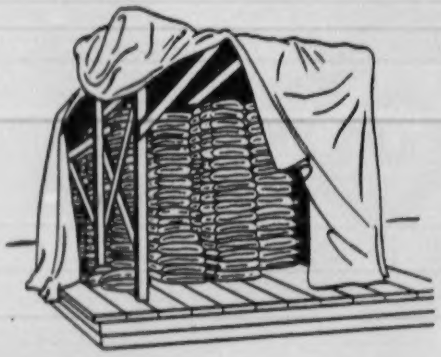


Figure 1. Cement Stored Under a Tarpaulin

thereby reaching the bottom sacks. Cement which does not come into contact with moist air will retain its quality indefinitely. Cement which has been stored for a long period of time may develop what is known as warehouse pack. This condition results from tight packing; however, the cement retains its quality. Warehouse pack can be corrected by rolling the sack on the floor. At the time of use, cement should be free-flowing and free of lumps. If the lumps are hard to break up, the cement should be tested to determine its suitability.

## Water for Concrete

Water which is safe for drinking is safe for making concrete. However, water which is not potable (fit for drinking) may still be satisfactory for making concrete. If there is a reason to suspect the suitability of the water supply, tests may be run on mortar made with the suspected water. Normally, the tests are made on the mortar at the age of 28 days but in emergencies a test may be run after 24 hours, with a confirming test made at 7 days. If the engineer finds that the mortar made with the test water is at least 90 percent as strong as mortar made with water known to be practically pure, the water is considered usable. Water containing strong acid or alkaline inorganic salts are not acceptable. Seawater is sometimes used for mixing concrete and with satisfactory results. Tests have shown that seawater gives compressive strengths from 10 to 20 percent lower than fresh water. This reduction in strength may be corrected by using somewhat less mixing water and somewhat more cement. There is no evidence available indicating that the use of seawater for mixing promotes deterioration of concrete.

1F- 75-1090

## Aggregate

Concrete aggregates are strong and durable materials which constitute the major bulk of the concrete. They should consist of clean, uncoated particles having a good distribution between size limits. Materials commonly used as concrete aggregates are natural sands and gravels, crushed rock, crushed slag, or other similar materials. Most concrete consists of 68 to 78 percent aggregate.

HARMFUL SUBSTANCES. Normally aggregates are rejected or repossessed if they contain soft, friable, thin, flaky, elongated, or laminated particles, totaling more than 3 percent by weight. Silt and fines should be held between the limits of 3 and 10 percent passing a No. 100 sieve. If all of these types of materials are present, their combined amount may not exceed 5 percent by weight of the combined aggregate. Clay, silt, and rock dust are very harmful because they reduce the strength and durability of concrete. They reduce strength and durability by inhibiting the proper bond between the cement and aggregate particles.

GRADATION. Gradation of aggregate is a major factor in the workability, water requirement, and strength of concrete. Normally, the maximum size of aggregate should not exceed 2 inches, and the largest particles should not be over one-third the pavement thickness. Fine and coarse aggregate are normally separated by the No. 4 sieve. Those passing through the No. 4 sieve are classified as fine aggregates and those remaining are coarse aggregates. The fine and coarse aggregates are handled separately to permit adjusting the proportion of each to produce a dense and workable mixture.

The gradation or particle size of aggregate is determined by a sieve analysis. The suggested standard sieves used for this purpose are listed below.

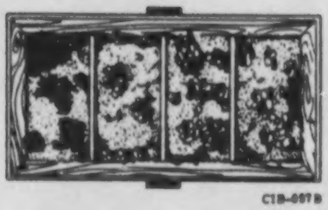
| Fine Aggregates | Coarse Aggregates |
|---|---|
| 4 | 3 inches |
| 10 | 1-1/2 inches |
| 20 | 3/4 inches |
| 30 | 3/8 inches |
| 40 | #4 |
| 60 | |
| 100 | |
| 200 | |

Other requirements for aggregate are shown in figure 2.

| Type Aggregate | Requirements | Sieve Size |
|---|---|---|
| Fine Aggregate (sand) | Hard<br>Strong<br>Subrounded or Cubical<br>Durable<br>Well Graded<br>Clean | Pass #4<br>Retained on #200 |
| Coarse Aggregate (gravel) | | Pass 3 inch<br>Retained on #4 |

Figure 2. Aggregate Size and Requirements

Figure 3 shows how a well-graded coarse aggregate looks after being separated into three sizes. From left to right in the separated aggregate: 3/4" to 1," 1/2" to 3/4," 3/8" to 1/2," and 1/4" to 3/8." Note how smaller pieces fit in among larger ones in the mixed aggregate.



CIB-097B

Figure 3. Well-Graded Coarse Aggregate

Figure 4 is a sample of well-graded sand before and after separating into various sizes. Particles vary from fine to those just passing the No. 4 sieve.

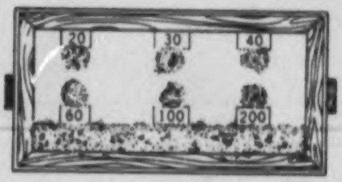


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Figure 4. Well-Graded Sand

STOCKPILES. Normally aggregate is stored in stockpiles built up in layers of uniform thickness. Stockpile buildups should be performed in a manner which prevents the separation of the large and small particles. Every batch of aggregate which comes to the mixer should be of the same composition and consistency. Therefore, stockpiles should not be formed in high cone shapes or allowed to run down slopes because this causes separation. Aggregate should be placed in layers and in individual units not larger than one truckload. Damp, fine aggregate has less tendency to segregate than dry, fine aggregate. To further prevent separation, never allow aggregate to free-fall from the conveyor belt and make the haul distances as short as possible. If batching equipment is used, some of the aggregate will be stored in bins. Bins should be loaded by allowing the material to fall vertically over the outlet. Chuting the material at an angle against the side of the bin causes segregation of particles. Correct and incorrect methods of storing aggregate are shown in figure 5.

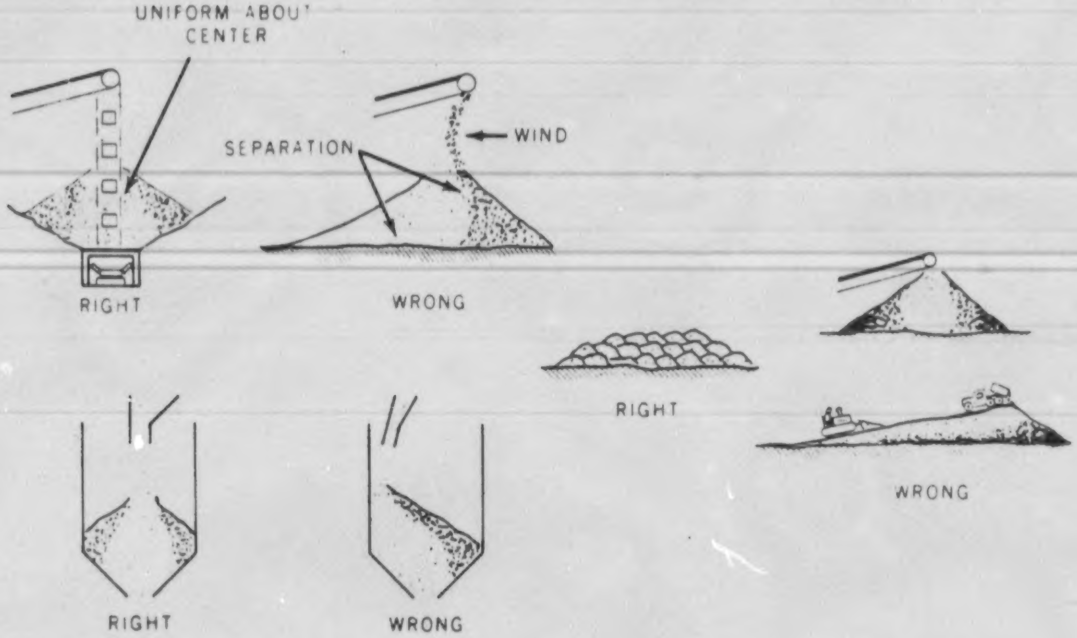

Figure 5. Methods of Handling Aggregate

PHYSICAL PROPERTIES. Specific gravity, absorption, and moisture content of aggregate are the important properties considered in designing concrete mixes. The specific gravity is used to determine the voids in the component. The average specific gravity of sand, gravel, and limestone is 2.65; the average value for granite is about 2.70; and for traprock, about 2.95. The personnel responsible for making the test of specific gravity and absorption of aggregate should follow the procedure outlined in "Design and Control of Concrete Mixtures," published by the Portland Cement Association.

The absorption capability and moisture content are used to obtain the water cement ratio. The absorption capability is also used to detect soft aggregate. Traprock and granite absorb water to the extent of about 1/2 percent of its dry weight; good average sand, gravel, and limestone absorb about 1 percent; and porous sandstone absorbs about 7 percent. In very light, porous aggregate, the absorption may be as high as 25 percent. Aggregate which absorbs more than 1 and 1/2 percent by weight, after 24 hours submergence in water at $70^{\circ}$F, is checked for durability by comparative freezing and thawing tests if it is to be used in an area where freezing occurs.

COMPOSITION. The abrasion resisting medium in concrete is the aggregate. Traprock, gravel, and granite are usually the best materials for coarse aggregate and natural sands are better for fine aggregate.

ORGANIC IMPURITIES. Natural sands sometimes contain organic materials which are detrimental to the hardening of concrete and should be tested to determine the amount. Two methods of testing for organic content can be used on the job. One test is known as the quart jar method. This method is accomplished by placing 2 inches of sand in a quart jar and adding water until the jar is about three-quarters full. This mixture must be vigorously shaken for 1 minute and allowed to stand for 1 hour. If more than 1/8-inch layer of silt forms on the surface of the sand, the silt content is too high. See figure 6. Sand containing excessive silt must be discarded or washed to remove the silt. Small amounts of sand can be successfully washed on a device similar to the one shown in figure 7.

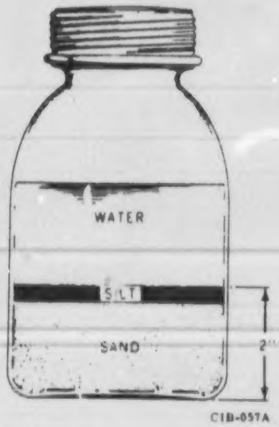
WATER
SILT
SAND
2"
CIB-057A

Figure 6. Quart Jar Method of Determining Silt Content of Sand

BANK RUN GRAVEL. Sand and gravel suitable for concrete often are found as bank run gravel. This means the natural mixture of sand, gravel, and stone as it comes from a gravel bank.

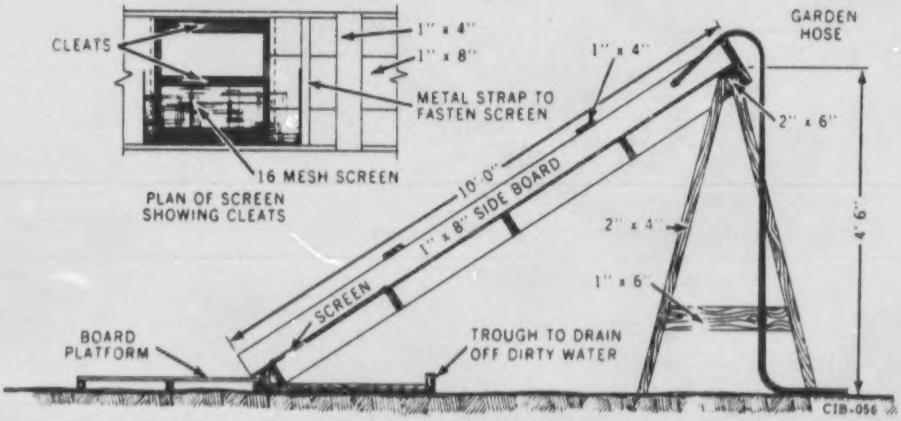
CLEATS
1" x 4"
1" x 8"
METAL STRAP TO FASTEN SCREEN
16 MESH SCREEN
PLAN OF SCREEN SHOWING CLEATS
GARDEN HOSE
1" x 4"
2" x 6"
10'-0"
1" x 8" SIDE BOARD
2" x 4"
4'-6"
1" x 6"
SCREEN
BOARD PLATFORM
TROUGH TO DRAIN OFF DIRTY WATER
CIB-056

Figure 7. Device for Washing Sand and Gravel with High Silt Content

Bank run gravel, however, is rarely found in the proper mixture of sizes to make the best quality concrete; therefore, it is usually necessary to screen it into two sizes. Gravel not larger than 1 1/2 inch in diameter is suitable for most construction. Occasionally, for thick foundations and other heavy sections, larger stone can be used to advantage. However, the larger stones are likely to prove troublesome in thin sections like water tank walls and thin foundations. Where big stones occur in large number in bank run gravel, it is advisable to screen the material first over a 1 1/2-inch screen. Material failing to pass this screen is discarded. Material passing through the 1 1/2-inch screen should then be shoveled over a No. 4 screen. That part passing through the No. 4 screen is the sand and material remaining is gravel.

Frequently this aggregate (sand and gravel) is not clean enough for use until it is washed to remove silt, clay, or other materials detrimental to good concrete mixtures. Since clean aggregates are so essential to quality concrete, washing is well worth the effort.

## WATER-CEMENT RATIO

The amount of water to use when mixing concrete is of critical importance. If too much water is used, it will evaporate and leave undesirable voids in the concrete. Water used for concrete is usually expressed in terms of gallons per sack of cement. This ratio may also be expressed as the ratio of the weight of the sack of cement. For example, if 50 pounds of water per sack of cement is used and the weight of one sack of cement is 94 pounds, the water-cement ratio is 50/94 or 0.53. However, the amount of water to be used will be given in gallons per sack of cement in this study guide

## CONCRETE ADDITIVES

There are several agents which can be added to concrete to make it work easier, set faster, and resist freezing and thawing better. The most important of these agents is the addition of calcium chloride and air-entrainment agents.

### Calcium Chloride

The addition of calcium chloride (a crystalline compound used in its dry state as a drying agent) to a concrete mix accelerates the rate of hardening. This is an added advantage in cold weather operations because the period during which the concrete must be protected from freezing is shortened. However, if used in warm weather, there is the probability of flash set (rapid hardening of the concrete). There are two types of calcium chloride: flake and pellet. Two percent of the flake type or 1.6 percent of the pellet type (by the weight of the cement used) is generally the maximum amount to use. When you use the flake type, approximately 2 pounds of calcium chloride per sack of cement is recommended.

### Lime

In concrete, lime functions as a plasticizer, making the concrete easier to place, reducing honeycombing, and improving the watertightness and appearance of the finished concrete. Lime is also added as a coating on metal reinforcement for concrete and masonry to improve its resistance to corrosion.

### Air-entraining

Air-entrained cement is any cement in which an air-entrainment has been incorporated. This is done by blending the agents with the cement during manufacturing or adding them at the mixing site. If mixed at the site, the agent is added to the mixing water. Manufactured air-entraining cements are indicated by letter "A" in the type number (Type IA, Type IIA, Type IIIA, etc). Concrete made with this cement contains billions of extremely small entirely separated air bubbles per cubic foot of the concrete and these bubbles act very similarly to sand. The air volume is approximately 4 percent of the total volume. The presence of these air bubbles makes the concrete more resistant to freezing action. Although some reduction of strength results from the entrainment of air, this reduction is somewhat offset by reducing the water cement ration. In other words, at least one-half gallon less water per sack of cement can be mixed and still maintain the same workability. Air-entrainment is especially useful or pavement construction in severe climates where there is exceptional exposure to weathering, particularly the freezing and thawing cycles. The difference in types of cement can be shown in figure 8.

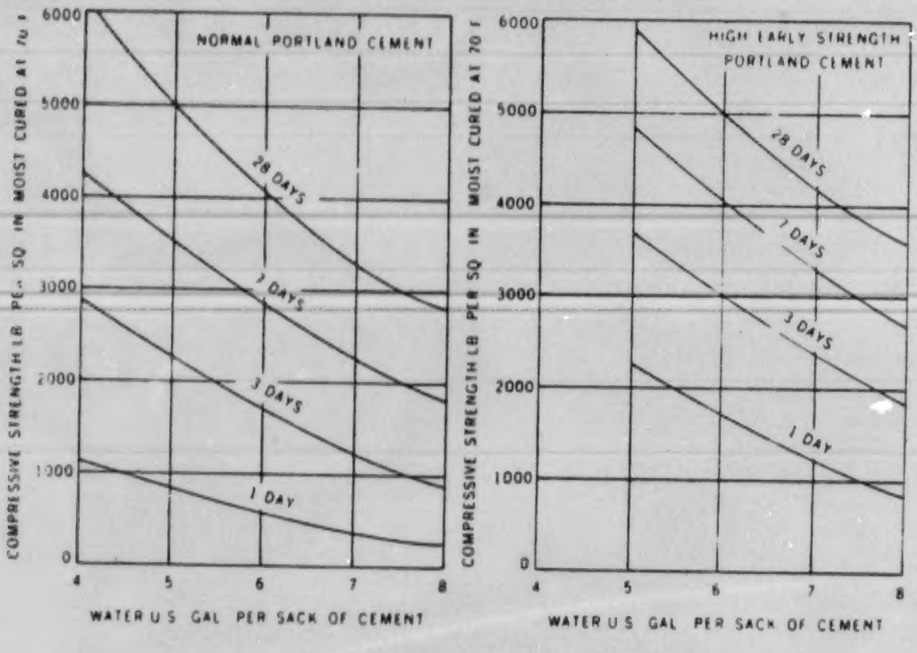

Figure 8. Age Strength Relations for Normal and High-Early Strength Portland Cement

## FACTORS AFFECTING CONCRETE STRENGTH

Each particle of aggregate is completely surrounded by cement-water paste and the spaces between the particles are completely filled with the paste if the concrete is completely mixed. This paste binds the aggregate into a solid mass and the strength of the concrete primarily depends upon the strength of the paste. The binding properties of the paste are due to chemical reaction (hydration) between the cement and water. All of the materials must be correctly proportioned to obtain the chemical reaction necessary to produce good concrete.

Compressive strength is the ability of a concrete slab to resist a crushing force and flexural strength is the ability to resist a breaking force.

The strength of concrete increases with time as shown in figures 9 and 10. These figures also show the compressive and flexural strength-time relations for concrete.

Table 1 gives the quantity of water to be used for concrete of a given strength.

| Gallons of water per sack of cement | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|
| Probable average 7-day strength in PSI | 4,400 | 3,500 | 2,800 | 2,200 | 1,800 |
| Probable average 28-day strength in PSI | 6,000 | 5,000 | 4,000 | 3,300 | 2,800 |

Table 1. Relation Between Mixing Water and the Compressive Strength of Concrete

A safety factor of 15 percent should be allowed when selecting the water content required. If 2,800 pounds per square inch concrete at 28 days is required, a water content corresponding to a strength of 3,200 pounds per square inch should be selected.

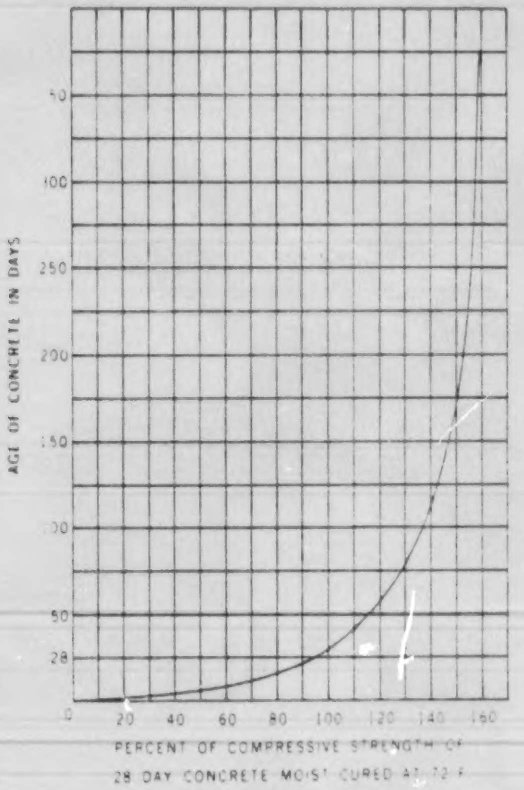

Figure 9. Compressive Strength-Time Relations for Concrete

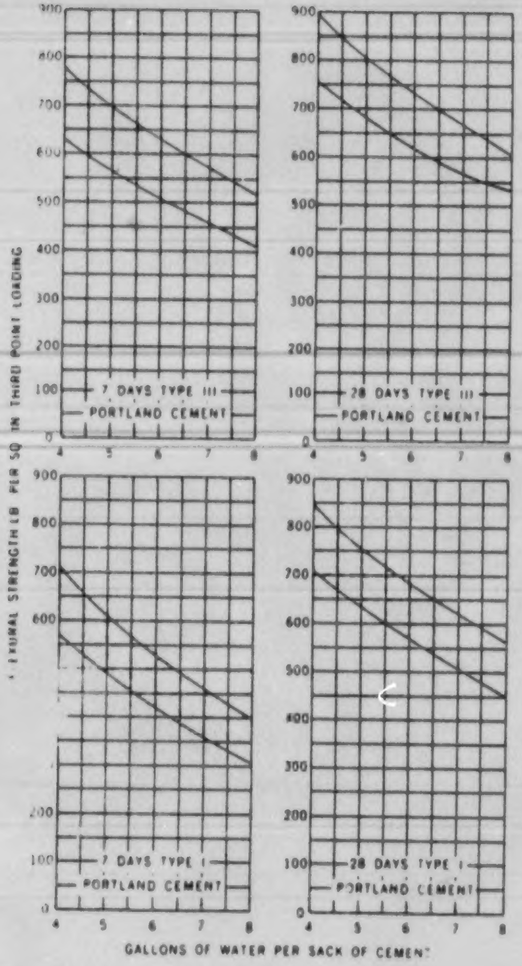

Figure 10. Flexural Strength-Time Relations for Concrete

## INGREDIENTS OF STANDARD CONCRETE MIXES

The ingredients of a standard concrete mix are one part cement, two parts sand, and three parts gravel (1:2:3), with six gallons of water. This ratio is measured by volume. A trial or design mix is made by weight.

A bag of cement weighs 94 pounds and contains one cubic foot. A gallon of water weighs 8.33 pounds; one cubic foot contains 7.5 gallons.

## METHODS OF PREPARING STANDARD MIXES

### Mixing

The objective of mixing is to insure that the aggregate is well distributed throughout the concrete and each particle is fully coated with a film of cement paste. Concrete may be mixed by hand or in a mixer. The mixing should be done as close to the point where the concrete is to be used.

### Handmixing

Mixing concrete by hand can best be done in a mortar box (figure 11) or on a tight wooden platform which will not leak nor absorb water from the concrete. A measuring device (pail, measuring box, figure 12, shovel or wheelborrow) can be used to obtain the correct amount of sand.

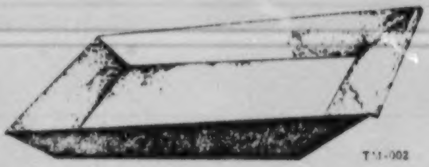

Figure 11

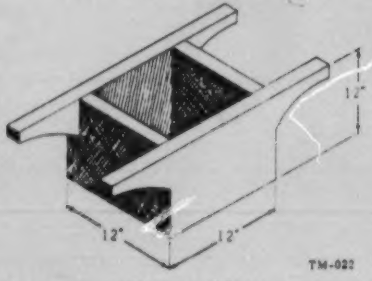

Figure 12.

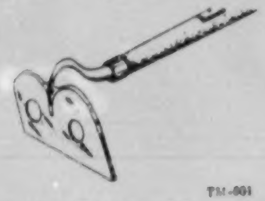

Figure 13

To handmix concrete, the sand should be uniformly in the center of the platform. Next, the amount of cement should be uniformly spread over the sand. The sand and cement should then be thoroughly mixed with a mortar hoe, figure 13. When the ingredients are well mixed, the combination is of uniform gray color, free from streaks. Then the coarse aggregate should be measured and mixed with the sand and cement until it is well distributed in the mass. At least three or four complete turnings are necessary to properly distribute the aggregate in the ingredients.

After the dry ingredients are completely mixed, a depression is made in the center of the pile to hold water. A specified amount of water is measured and slowly poured into the depression as shovelsful of the ingredients are turned into the water. Then the remainder of the water is added and the ingredients are mixed until the concrete has the proper plasticity.

### Machine Mixing

A concrete mixer is best suited for mixing concrete for large jobs. A manually charged mixer should have the dry materials measured into the hopper and about 10 percent of the water into the mixer drum. As the dry ingredients are poured into the drum, approximately 80 percent of the water should be added along with them. After all of the other ingredients are in the drum, the remaining 10 percent of the water is added to the mix. The length of time concrete should be mixed varies with different mixers. Specifications usually require concrete to be mixed a minimum time of 1 minute for the first cubic yard and an additional 15 seconds for each additional one-half cubic yard. However, the manufacturer's or technical order instructions regarding the operation of a specific machine should be followed.

## SLUMP TEST

### Consistency

A concrete mix with a fluid consistency flows easily into forms and around reinforcing steel. A stiff concrete mix does not flow readily and usually requires additional labor or special equipment to place it. Immediately after being mixed, concrete should be plastic, neither fluid nor stiff.

The means of measuring consistency is the slump test. To perform this test, concrete mix is placed in a cone-shaped form and rodded or tamped. After the concrete is tamped and the form is removed, the concrete slumps to a position of equilibrium. The amount of slump is then measured in the manner illustrated in figure 14.

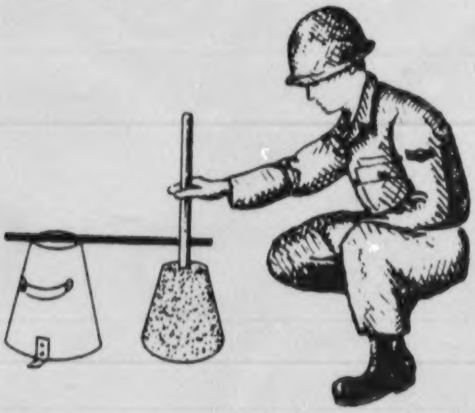

Figure 14. Slump Test

The greater the measured slump, the more fluid is the mix. The concrete should have no more slump than necessary to enable the placing crew to place it. If more slump is needed, it should be obtained by reducing the amount of sand and coarse aggregate rather than adding more water. The normal or standard concrete mix is based on the 1:2:3 with 6 gallons of water. That is, 1 part cement (1 bag or 1 cu ft), 2 parts fine aggregates, 3 parts coarse aggregates and 6 gallons of water per sack. This mixture will yield a sump of a maximum of 3 inches and the minimum of 2 inches.

Workability refers to the ease with which a certain concrete mix can be placed in a particular position. However, this term has separate use. For example, a concrete containing large aggregate particles with a stiff consistency would be workable in a large mass, but would not be working in a thin wall with closely spaced reinforcing bars. Table 2 lists the recommended slumps for various types of construction.

TABLE 2
Recommended Slumps for Various Types of Construction*

| Type of Construction | Slump in inches | |
|---|---|---|
| | Maximum | Minimum |
| Reinforced foundation walls and footings | 4 | 1 |
| Plain footings, caissons, and substructure walls | 4 | 1 |
| Slabs, beams, and reinforced walls | 5 | 2 |
| Building columns | 5 | 2 |
| Pavements | 3 | 2 |
| Heavy mass construction | 3 | 1 |

*When high-frequency vibrators are to be used, the table values should be reduced by one-third.

## Trial Mix

Aside from producing a material having the required strength, durability, and watertightness, economy is the important factor in designing concrete mixes. As much fine and coarse aggregate as possible should be used, since this material is cheaper than cement. The trial-mix method of obtaining the proper amounts of fine and coarse aggregate to be combined with each sack of cement should be used. In most cases, the required strength of concrete has been established by the engineer responsible for the design of the project. The compressive strength of concrete made with various amounts of water was given in Table 2. The amount of water selected includes free water present in the aggregate plus water added at the mixer.

Select the required slump from Table 3 if the designer has not furnished this information. The amount of slump required will vary with the type of construction. Thin members and those which contain large amounts of reinforcing steel require more fluid or plastic mixes than do large masses of concrete with little reinforcing steel. Selecting the proper slump is important since it affects the amount of aggregate to be used and the amount of labor required to place the concrete.

When using any new combinations of fine and coarse aggregate, trial mixes should be made to determine the amount of each to be used per sack of cement. In small or unimportant work, an arbitrary mix of 1 part cement, 2 1/2 parts sand, and 3 1 2 parts gravel (1:2 1/2:3 1/2) may be used. However, the amount of aggregate will vary with the water cement ratio previously decided upon.

The percentage of water by weight which aggregate will absorb varies. The approximate quantity in gallons of surface water or free (unabsorbed) water carried by a cubic foot of average aggregate is as follows:

| Maximum size of coarse aggregate | Water-cement ratio (U.S. gal. per sack | Slump (inches) | Proportions by dry weight | Proportions by volume (dry-compacted) | Materials for 1 batch in 14-cubic-foot mixer, assuming average damp materials | | | | Yield (cu. ft. of concrete per 1 bag batch) | Unit quantities of materials for 1 cubic yard of concrete | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Water (U.S. gal.) | Cement (94 lb. sacks) | Fine (cu. ft.) | Coarse (cu. ft.) | | Cement (94 lb. sacks) | Weight (damp) | | Volume (damp loose) | |
| | | | | | | | | | | | Fine (tons) | Coarse (tons) | Fine (cu. yd.) | Coarse (cu. yd.) |
| 1 inch | 5 | 1/2 to 1 | 1 2.0 3.1 | 1 1.7 2.8 | 9.7 | 3 | 6.1 | 8.9 | 4.07 | 6.64 | 0.65 | 0.99 | 0.51 | 0.73 |
| | | 3 to 4 | 1 1.7 2.5 | 1 1.5 2.2 | 14.1 | 4 | 7.2 | 9.3 | 3.56 | 7.59 | .63 | .91 | .49 | .67 |
| | | 5 to 7 | 1 1.4 2.0 | 1 1.2 1.8 | 15.2 | 4 | 5.7 | 7.6 | 3.11 | 8.68 | .60 | .83 | .47 | .61 |
| | 5 1/2 | 1/2 to 1 | 1 2.2 3.4 | 1 1.9 3.0 | 10.7 | 3 | 6.9 | 9.5 | 4.40 | 6.14 | .66 | 1.00 | .51 | .73 |
| | | 3 to 4 | 1 1.9 2.9 | 1 1.6 2.6 | 11.5 | 3 | 5.8 | 8.3 | 3.95 | 6.83 | .64 | .95 | .50 | .70 |
| | | 5 to 7 | 1 1.6 2.3 | 1 1.4 2.1 | 16.4 | 4 | 6.8 | 8.9 | 3.50 | 7.71 | .60 | .85 | .47 | .62 |
| | 6 | 1/2 to 1 | 1 2.5 3.8 | 1 2.2 3.4 | 11.4 | 3 | 7.9 | 10.8 | 4.92 | 5.48 | .67 | 1.00 | .52 | .73 |
| | | 3 to 4 | 1 2.2 3.4 | 1 1.9 3.0 | 12.2 | 3 | 6.9 | 9.6 | 4.47 | 6.03 | .65 | .98 | .51 | .72 |
| | | 5 to 7 | 1 1.9 2.8 | 1 1.6 2.5 | 13.1 | 3 | 5.8 | 8.0 | 3.95 | 6.83 | .64 | .92 | .50 | .67 |
| | 6 1/2 | 1/2 to 1 | 1 2.8 4.1 | 1 2.4 3.7 | 8.1 | 2 | 5.8 | 7.9 | 5.32 | 5.07 | .70 | 1.00 | .54 | .73 |
| | | 3 to 4 | 1 2.5 3.7 | 1 2.1 3.3 | 13.1 | 3 | 7.6 | 10.5 | 4.86 | 5.55 | .68 | .98 | .53 | .72 |
| | | 5 to 7 | 1 2.2 3.3 | 1 1.9 3.0 | 13.7 | 3 | 6.9 | 9.6 | 4.54 | 5.95 | .64 | .94 | .50 | .69 |
| | 7 | 1/2 to 1 | 1 3.0 4.3 | 1 2.6 3.9 | 8.8 | 2 | 6.3 | 8.3 | 5.63 | 4.80 | .70 | 1.00 | .54 | .73 |
| | | 3 to 4 | 1 2.7 4.0 | 1 2.3 3.6 | 9.3 | 2 | 5.5 | 7.6 | 5.24 | 5.15 | .68 | .99 | .53 | .72 |
| | | 5 to 7 | 1 2.4 3.6 | 1 2.1 3.2 | 14.7 | 3 | 7.6 | 10.2 | 4.86 | 5.55 | .65 | .96 | .51 | .70 |
| | 8 | 1/2 to 1 | 1 3.4 4.9 | 1 2.9 4.4 | 10.2 | 2 | 7.0 | 9.4 | 6.29 | 4.30 | .72 | 1.01 | .56 | .74 |
| | | 3 to 4 | 1 3.1 4.7 | 1 2.7 4.2 | 10.5 | 2 | 6.5 | 8.5 | 6.04 | 4.47 | .68 | 1.01 | .53 | .74 |
| | | 5 to 7 | 1 2.8 4.4 | 1 2.4 3.9 | 11.0 | 2 | 5.8 | 8.3 | 5.64 | 4.79 | .66 | 1.01 | .51 | .74 |
| 2 inches | 5 | 1/2 to 1 | 1 2.0 3.7 | 1 1.7 3.3 | 9.3 | 3 | 6.1 | 10.5 | 4.40 | 6.13 | .60 | 1.06 | .47 | .78 |
| | | 3 to 4 | 1 1.7 3.0 | 1 1.5 2.7 | 10.2 | 3 | 5.4 | 8.6 | 3.88 | 6.96 | .58 | 1.00 | .45 | .73 |
| | | 5 to 7 | 1 1.4 2.5 | 1 1.2 2.2 | 14.8 | 4 | 5.7 | 9.3 | 3.36 | 8.00 | .55 | .96 | .43 | .70 |
| | 5 1/2 | 1/2 to 1 | 1 2.3 3.9 | 1 2.0 3.5 | 10.1 | 3 | 7.2 | 11.1 | 4.79 | 5.64 | .64 | 1.06 | .50 | .78 |
| | | 3 to 4 | 1 2.0 3.4 | 1 1.7 3.0 | 11.1 | 3 | 6.1 | 9.6 | 4.30 | 6.28 | .61 | 1.03 | .47 | .76 |
| | | 5 to 7 | 1 1.7 2.9 | 1 1.5 2.6 | 11.7 | 3 | 5.4 | 8.3 | 3.88 | 6.96 | .58 | .97 | .45 | .71 |
| | 6 | 1/2 to 1 | 1 2.6 4.4 | 1 2.2 3.9 | 7.3 | 2 | 5.3 | 8.3 | 5.24 | 5.15 | .65 | 1.06 | .51 | .78 |
| | | 3 to 4 | 1 2.2 3.8 | 1 1.9 3.4 | 11.9 | 3 | 6.9 | 10.8 | 4.73 | 5.70 | .62 | 1.04 | .48 | .76 |
| | | 5 to 7 | 1 2.0 3.4 | 1 1.7 3.0 | 12.6 | 3 | 6.1 | 9.6 | 4.34 | 6.22 | .61 | 1.01 | .47 | .74 |
| | 6 1/2 | 1/2 to 1 | 1 2.8 4.7 | 1 2.4 4.2 | 7.9 | 2 | 5.8 | 8.9 | 5.64 | 4.80 | .66 | 1.07 | .51 | .79 |
| | | 3 to 4 | 1 2.5 4.2 | 1 2.1 3.8 | 8.5 | 2 | 5.1 | 8.1 | 5.18 | 5.21 | .64 | 1.05 | .50 | .77 |
| | | 5 to 7 | 1 2.2 3.8 | 1 1.9 3.4 | 13.4 | 3 | 6.9 | 10.8 | 4.80 | 5.62 | .61 | 1.03 | .47 | .76 |
| | 7 | 1/2 to 1 | 1 3.0 5.0 | 1 2.6 4.5 | 8.5 | 2 | 6.3 | 9.5 | 6.03 | 4.48 | .66 | 1.07 | .51 | .79 |
| | | 3 to 4 | 1 2.7 4.5 | 1 2.3 4.0 | 9.1 | 2 | 5.5 | 8.5 | 5.51 | 4.90 | .64 | 1.05 | .50 | .77 |
| | | 5 to 7 | 1 2.4 4.1 | 1 2.1 3.7 | 9.5 | 2 | 5.1 | 7.9 | 5.18 | 5.21 | .61 | 1.03 | .47 | .76 |
| | 8 | 1/2 to 1 | 1 3.4 5.5 | 1 2.9 4.9 | 9.9 | 2 | 7.0 | 10.4 | 6.62 | 4.07 | .68 | 1.07 | .53 | .79 |
| | | 3 to 4 | 1 3.1 5.1 | 1 2.7 4.6 | 10.3 | 2 | 6.5 | 9.8 | 6.29 | 4.30 | .65 | 1.05 | .51 | .77 |
| | | 5 to 7 | 1 2.8 4.6 | 1 2.4 4.1 | 10.9 | 2 | 5.8 | 8.7 | 5.77 | 4.68 | .64 | 1.03 | .50 | .76 |

Table 3. Properties, Batch Quantities, and Unit Quantities for Concrete Mixes

| | |
|---|---|
| • Very wet sand | 3/4 to 1 |
| • Moderately wet sand | about 1/2 |
| • Moist sand | about 1/4 |
| • Moist gravel or crushed rock | about 1/4 |

The water in damp sand forms a film on the grains, fluffing them apart to an extent much greater than the actual volume of the sand. This bulking is greater at a moisture content of about 6 percent of dry weight at which value the bulking may be as much as 20 or even 30 percent of the dry volume. Additional water packs the sand and decreases the bulking. Sand has about the same volume when completely flooded as it has when measured dry and loose. Bulking is allowed for when measuring sand by volume and is determined by tests if necessary. However, the effect of moisture on the volume of coarse aggregate is negligible.

Allowing for free water and bulking, trial batches (1/10 sack of cement mixed by hand) or full-size mixer batches are made. The proportions for the first trial mix for the required water-cement ratio and selected slump are given in Table 3.

Aggregate proportions should be adjusted to give the desired workability without changing the water-cement ratio. If the first batch looks and handles like good concrete and it is readily workable, small increases in the coarse aggregate can be tried to reduce the cement demand. If the mixture is too harsh, too dry, or otherwise unworkable, adjustments are made in the fine or coarse aggregate approaching the proportions given for the next greater slump.

The following is given as an illustrative example of aggregate proportions:

A 2-sack batch using 1 inch maximum size aggregate, water cement ratio of 7 gallons per sack, slump of 3 to 4 inches, and dry compacted volumetric proportions of 1:2.3:3.6 is selected for trial. Batch quantities for 1 batch in a 14 cubic foot mixer are:

| | |
|---|---|
| • Water | 9.3 gallons |
| • Cement | 2 sacks |
| • Fine aggregate | 5.5 cubic feet (damp-loose) |
| • Coarse aggregate | 7.6 cubic feet (damp-loose) |

These quantities were taken from Table 3 under the column headed "Materials for 1 batch in 14-cubic foot mixer, assuming average damp materials." The quantities listed in this column are based on the following assumptions: Moderately wet sand carrying 1/2 gallon of free moisture per cubic foot with damp-loose volume 1.20 times the dry-compacted volume; moist gravel carrying 1/4 gallon of free moisture per cubic foot with damp-loose volume of 1.06 times dry-compacted volume. Water quantities have been adjusted for the moisture carried by the aggregate. The amount shown is to be added to the mixer. Batch quantities are for whole number of sacks of cement to give a batch quantity not greater than 14 cubic feet.

## SAFETY PRECAUTIONS

Some of the safety rules to observe when working with cement, concrete mixes, or concreting equipment are as follows:

- Do not stack cement more than eight bags in height.
- Do not lift a bag of cement without assistance.
- Wear goggles and clothing which covers as much of your body as possible.
- Wear goggles when chipping hardened concrete from mixers and tools.
- All mixers will be carefully positioned on the job to reduce any accident hazards.
- Skips on large machines will be protected by guardrails.
- Only the operator will raise the skip on his machine.
- When shutting down the mixer, the skip must be lowered.
- Only men in good health will operate mechanical concrete vibrators.

## SUMMARY

The ingredients of concrete are cement, sand, gravel and water. There are five types of Portland cement. Each type has its own characteristics and use. Water which is safe for drinking is safe for making concrete. Aggregate constitutes the major bulk of concrete. Fine aggregate (sand) is separated from coarse aggregate (gravel) by the number 4 sieve. One of the factors which determines the strength of concrete is the water-cement ratio. The ratio of water and cement is usually expressed as the gallons of water per bag of cement. The additives that are used in concrete to make it easier to work, set faster and resist freezing are calcium chloride, lime, and air-entraining. The ingredients of a standard concrete are one part cement, two parts sand, and three parts gravel. The two methods of mixing concrete are hand-mixing and machine mixing. The slump test measures the consistency of concrete.

## QUESTIONS

1. What is concrete?

2. What type of cement is used in large masses of concrete such as large dams?

3. How can warehouse pack be removed from stored cement?

4. What effect will clay, silt, and rock dust in the aggregate have on concrete?

5. What measures the separation of fine and coarse aggregate?
6. What is the purpose of adding lime to concrete?
7. How much flake-type calcium chloride is added per sack of cement to concrete?
8. What is an advantage of using air-entrained cement?
9. What is meant by the compressive strength of concrete?
10. When handmixing cement and sand what indicates when it is well mixed?
11. What is the normal mixing time for concrete in a concrete mixer?
12. What method is used to decrease the slump of a trial mix of concrete?

REFERENCES

CDC 55233, Masonry Specialist

## PREPARING FOR CONCRETING

### OBJECTIVE

Upon completion of this unit of instruction you will be able to:

- prepare a site for concrete by excavating and by stabilizing the subsoil and base course.
- compute the area and volume to be concreted and determine the amount of concrete required for a given project.

### INTRODUCTION

One of the most important steps in concreting is to prepare the base. A poorly prepared base will result in cracking, heaving, and shifting of the structure.

The method of preparing for concreting is covered under the following headings.

- Concrete Bed Preparation
- Equipment
- Computing Volumes

## CONCRETE BED PREPARATION

The first step in the construction of a slab is to prepare the subgrade. All sod and vegetable matter must be removed. Any soft or muddy places must be dug out and filled with granular material and thoroughly tamped. Exceptionally hard, compact spots must be loosened and tamped to provide the same bearing power as the remainder of the subgrade. When additional fill is required, the soil should be spread in layers 6 inches or less in depth and thoroughly compacted. It is best to extend the top of all fills at least one foot beyond the edge of the slab.

A well-compacted, well drained subgrade will not require a specially prepared base. However, subgrades which are water soaked much of the time should be provided with a six inch base of sand, gravel, crushed stone or cinders.

The strength of the subgrade determines the thickness of either the concrete or the base course. The base course is that fill material composed of a mixture of gravel, sand, and soil which, when compacted, serves as a support for the concrete.

## EQUIPMENT

The equipment required to compact the subgrade and fill material are the pneumatic tamper, shown in figure 15, and a gasoline-engine-driven vibrator tamper, figure 16.

The pneumatic tamper requires the use of a portable air compressor. This equipment is used for compacting small areas. The principle of operation of this tamper is similar to that of a jack hammer. You must wear steel toe safety shoes when compacting.

The operating principles of the vibrator tamper is the rotation of an eccentric shaft (off-center weight). The momemtum of this fast rotating, unbalanced shaft

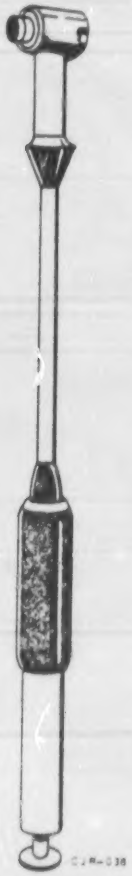

Figure 15. Pneumatic Tamper

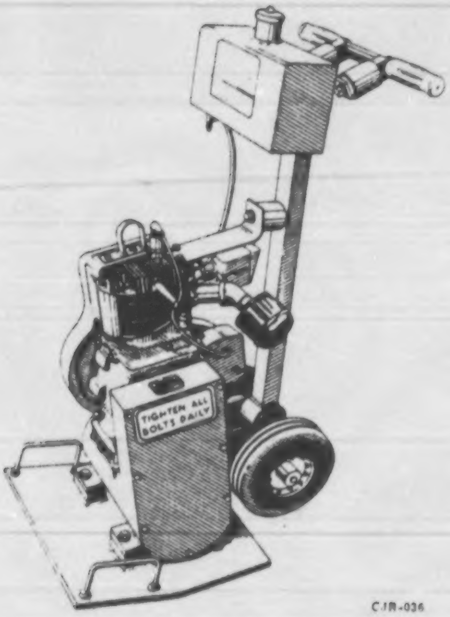

Figure 16. Vibrator Tamper

causes the tamper to vibrate. The shaft rotates at 2600 to 2800 revolutions per minute. This machine is used on level subgrade, but it is not used on brick, concrete, steel, or muddy and mucky surfaces. The depth of the material to be compacted should not exceed 12 inches.

After the engine has been started and warmed up, the operating speed may be obtained. This machine will move forward on its own power after it has tamped a base upon which to move. The operator only need to guide the machine.

## COMPUTING VOLUMES

To compute the quantity of concrete required for a concrete slab, you must know the dimensions: length (L), width (W), height (H). Volume is determined by multiplying these numbers together. However, the measurement of these dimensions must be in the same units, feet or yards. The formula for finding volume is

$$V = L \times W \times H$$

Volume is expressed in cubic feet if the measurements are expressed in feet, cubic yards when measured in yards.

If we are to compute the volume of a slab which is 12-feet wide, 18-feet long, and 6-inches high, we must first convert inches to feet. To convert inches to feet we divide the inches by 12 (12 inches is one foot). Using the formula, the volume will be

$$V = 18 \times 12 \times \frac{(6)}{(12)} = 108 \text{ cubic feet}$$

Since one cubic yard is equal to 27 cubic feet, we can find the number of cubic yards in the above problem. To convert cubic feet to cubic yards divide the volume in cubic feet by 27.

$$V = \frac{108}{27} = 4 \text{ cubic yards}$$

Should you need to know the area of a slab, you multiply only the width and length to obtain square feet. In the above problem the area would be 216 square feet.

$$A = L \times W$$
$$A - 18 \times 12 \text{ square feet}$$

## SUMMARY

It is important that an adequate base be established before placing concrete. Methods of preparing the base include removing the surface layer soil and compacting the subgrade and fill material. The fill is composed of granular material combined with small binding material.

The equipment used for compacting are the pneumatic tamper and the vibrator compactor.

Volumes are expressed in cubic feet or cubic yards.

## QUESTIONS

1. What is the first step in preparing for concreting?
2. Why must exceptionally hard compacted areas be loosened?
3. What is used to tamp subgrade?
4. Compute the volume in cubic yards in a slab which is 20-feet wide, 60-feet long and 8-inches high.

## REFERENCES

CDC 55233, Masonry Specialist

## REINFORCEMENT MATERIALS AND TOOLS

### OBJECTIVE

Upon completion of this study guide, you will recognize the need for reinforcing concrete; the materials and tools used in reinforcing concrete; and reinforcement installation techniques.

### INTRODUCTION

Most of us have seen modern football stadiums, hospitals, aircraft hangars or skyscrapers built of concrete. Have you ever wondered how these structures were built to withstand the loads that are imposed upon them ?

This study guide is designed to answer such a question. Since this study guide is introductory in nature, it will be necessary for the student to seek more comprehensive information from other courses. Information within this text will appear under the following headings.

- NEED FOR REINFORCING CONCRETE
- REINFORCEMENT MATERIALS
- INSTALLATION PROCEDURES
- TOOLS AND EQUIPMENT

### NEED FOR REINFORCING CONCRETE

Without the tensile strength of reinforcing steel and modern technology, it would be impossible to construct large concrete structures. Steel imbedded in the concrete makes it possible to erect buildings of this nature with large areas of floor space, free of load bearing support columns and partitions.

### REINFORCEMENT MATERIALS

Because of its tensile strength, steel is considered the best metal for reinforcing concrete. To make sure the reinforcement purposes are not defeated, there must be a good bond between the steel and the concrete. Bonds are created by natural means and are improved by mechanical means. The natural bonding of concrete to steel is brought about by the adhesion and shrinkage of concrete during hydration. This action causes the concrete to grip the metal tightly. The mechanical bonding of concrete to steel is brought about by twisting or otherwise deforming the metal. There are a variety of types and sizes of reinforcing material used to reinforce concrete.

4V- 75-109

Rods

Reinforcement steel rods are available in various sizes. A plain rod is a straight piece of steel stock that has not been twisted or deformed. A deformed rod is one that has been stamped or rolled to form rough designs on the outer surface. Plain and deformed reinforcing steel rods are shown in figure 17. The standard sizes of reinforcing rods are shown in figure 18.

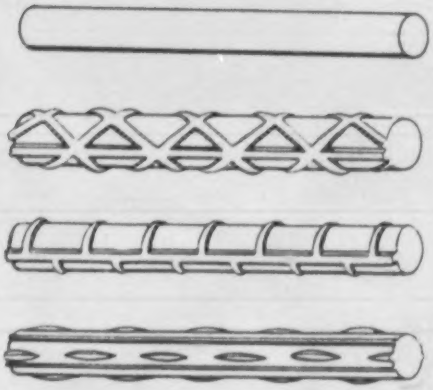

Figure 17. Types of Reinforcing Rods

| Bar No. | Diameter (in) | Area (sq in) | Weight (lb per ft) |
|---|---|---|---|
| - - - - - - - - | * 1/4 | 0.05 | 0.17 |
| 3 - - - - - - - | 3/8 | .11 | .38 |
| 4 - - - - - - - | 1/2 | .20 | .67 |
| 5 - - - - - - - | 5/8 | .31 | 1.04 |
| 6 - - - - - - - | 3/4 | .44 | 1.50 |
| 7 - - - - - - - | 7/8 | .60 | 2.04 |
| 8 - - - - - - - | 1 | .79 | 2.67 |
| 9 - - - - - - - | ** 11/8 | 1.00 | 3.40 |
| 10 - - - - - - - | ** 11/4 | 1.27 | 4.30 |
| 11 - - - - - - - | ** 13/8 | 1.56 | 5.31 |

*The 1/4-inch round bar can be obtained only as a plain bar.
**Approximate diameter. These round bars are equivalent in area to the obsolete 1-, 1 1/8-, and 1 1/4-inch square bars.

Figure 18. Standard Sizes of Steel Reinforcing Rods

## Wire

Woven wire is a steel reinforcing fabric having a rectangular or any number of different mesh patterns. The mesh can be purchased in several sizes with different size wire. The longitudinal wires are spaced and then tied in position by small transverse locking wires. See figure 19. Welded wire fabric is commonly used as steel reinforcement in footings, walls. and slabs. Variation in mesh are obtained by welding. Welding produces a more rigid. less distorted fabric than woven wire. A roll of welded wire fabric is shown in figure 20.

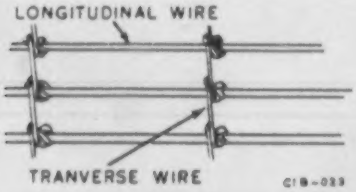
LONGITUDINAL WIRE
TRANVERSE WIRE
C18-023

Figure 19. A Section of Woven Wire

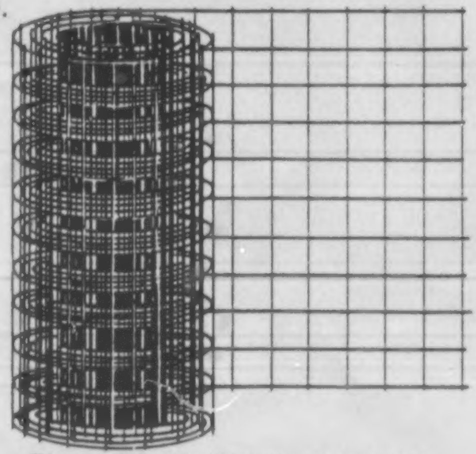

Figure 20. Welded Wire Fabric

## Supports and Spacers

A number of different devices are used to support and correctly space reinforcement steel. The steel rods must be correctly spaced in relation to each other, as well as the sides of the forms. Supports and spacers (also called chairs and saddles) are used in the forms to support and space the reinforcement steel. Slab bolsters, the proper size stone, and precast concrete blocks with metal ties (figure 21), are used to support the steel. Stirrups are used to support reinforcing material in concrete girders and beams. Several types of supports and spacers are shown in Fig. 22.

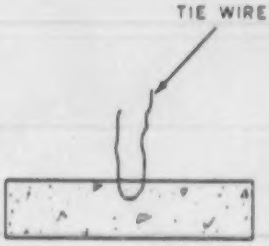

Figure 21. Precast Concrete Block

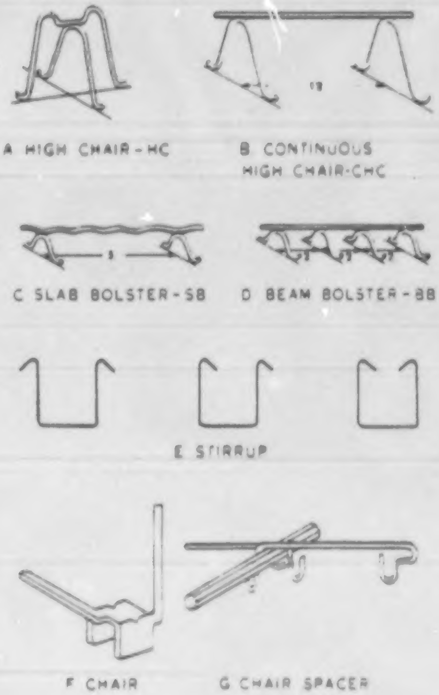
A HIGH CHAIR - HC
B CONTINUOUS HIGH CHAIR-CHC
C SLAB BOLSTER - SB
D BEAM BOLSTER - BB
E STIRRUP
F CHAIR
G CHAIR SPACER

Figure 22. Types of Supports and Spacers

## Anchors

Steel reinforcing rods must be securely anchored at the ends. Three types of anchors are shown in figure 23. They are large washers and nuts, right angle bends, and hooks.

## Installation Procedures

The construction of the reinforcing units and the form work for the concrete should be built simultaneously so there will be no loss of time. The type, size, shape, and placement of reinforcing materials are specifically covered in the drawings and specifications for the structure. Walls, floors, and columns are three of the principal structures you will be reinforcing.

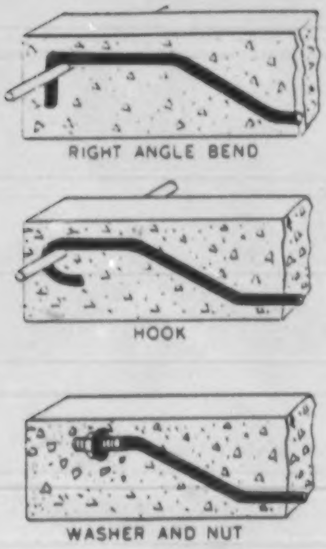

Figure 23. Types of Anchors

## Floors

Steel rods are used to reinforce concrete floors containing girders and beams. The reinforcements are generally placed parallel with girders and perpendicular to beams. Steel in place in a floor slab is shown in figure 24. Also, figure 25 illustrates reinforcing unit placed in a form. The arrow points out the small precast concrete block that is used to support, fasten, and correctly space the unit. Before placing concrete, be sure the reinforcing material is tied where the steel rods intersect. Before placing reinforcing material always check to see that it is free of loose scale, rust, and other foreign matter which will interfere with the bond between the concrete and the steel.

The height of the slab bolsters and high chairs in figure 24 depends on the specifications for the job. The height of the supports used to hold the reinforcing material in concrete slab is determined by the concrete protective cover specified. Footing and other principal structural members should have at least 3 inches of concrete between the steel reinforcement and the ground and a 2-inch protective covering of concrete above the steel reinforcements.

## Walls

Wire mesh and steel reinforcing rods are used for reinforcing concrete walls. The types of materials used will depend on the strength required. If wire mesh is used, the wire is attached to the wall with suitable chair spacers which support and space it correctly. If reinforcing rods are used, they will be connected to the wall, as shown in figure 26.

The placement of steel in walls is the same as placing steel for a concrete slab or floor, except that the steel is erected in place rather than preassembled. Note, in figure 26, that horizontal steel is tied to vertical steel wherever the two intersect. Eighteen-gage soft annealed iron wire is used in making ties.

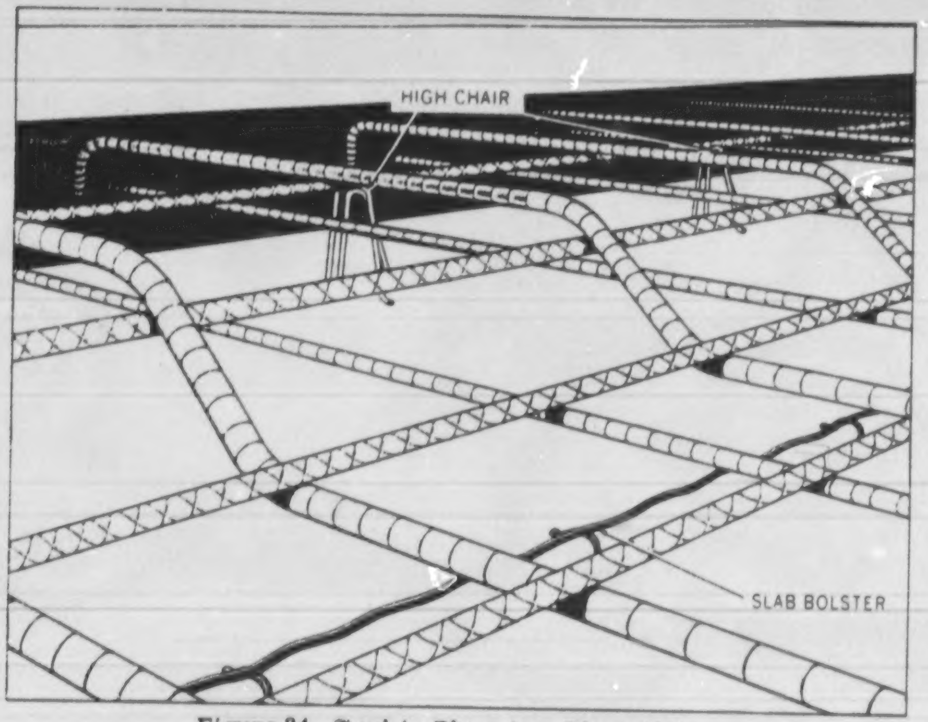
HIGH CHAIR
SLAB BOLSTER

Figure 24. Steel in Place in a Floor Slab

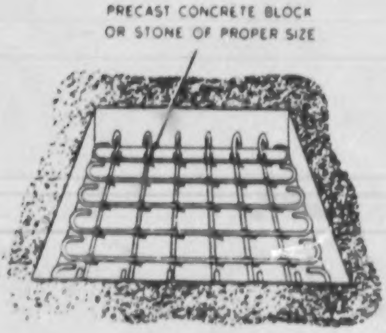
PRECAST CONCRETE BLOCK
OR STONE OF PROPER SIZE

Figure 25. Steel Placed in a Footing

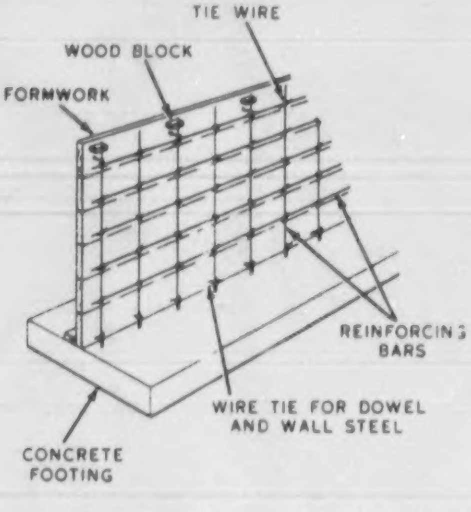
TIE WIRE
WOOD BLOCK
FORMWORK
REINFORCING
BARS
WIRE TIE FOR DOWEL
AND WALL STEEL
CONCRETE
FOOTING

Figure 26. Reinforcing Rods in a Concrete Wall

The wooden blocks at the top of the wall, figure 10, are used to space the steel reinforcement a predetermined distance from the form-work. The wire ties at the top and the bottom of the form-work serve the same purpose as the wooden blocks, as well as to hold the steel in place.

Holes are drilled through the form-work, and the wire ties are passed through the holes. They are connected to boards on the other side to hold the wire in place. The wooden blocks are removed from the top of the form when the form is filled with concrete to the level of the blocks. When you construct high walls (6 feet or more) use additional ties between the top and the bottom of the form-work.

## Columns

Steel rods and wire ties are used to build reinforcing units for columns. Steel reinforcing units are built in sections, as shown in figure 27, and the number of sections used depends upon the height of the column. Where two sections are connected, they overlap each other, as shown in figure 28, and they are secured with wire ties.

After the reinforcement is in place, the form-work is built around it and the steel is attached to the form with wire ties, as shown in figure 29.

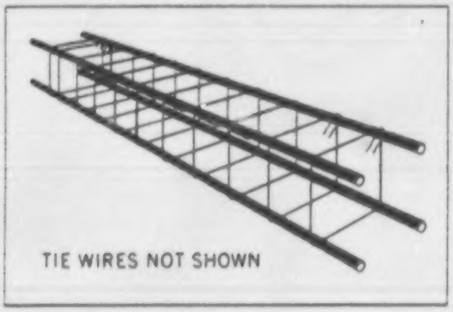

Figure 27. Column Reinforcing Steel Assembled

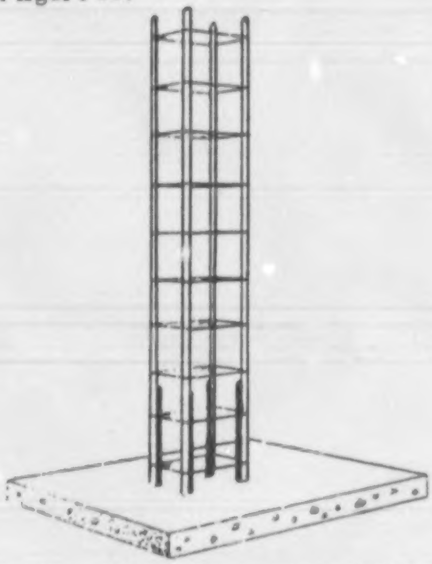

Figure 28. Column Reinforcing Steel in Place

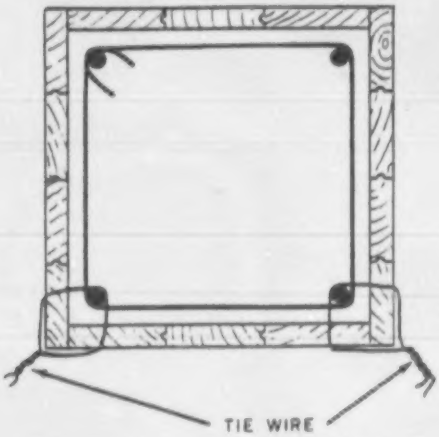

Figure 29. Method of Holding Column Steel in Place

When large numbers of reinforcing rods of various lengths and shapes are required, they are bent on a bar-bending table, as shown in figure 30. Shears are available that will cut the largest size used for reinforcing material. Small and large bolt cutters may also be used. For tieing the steel, a pair of wire cutters is used to cut the wire and a pair of pliers is used to tighten the tie wire around the steel.

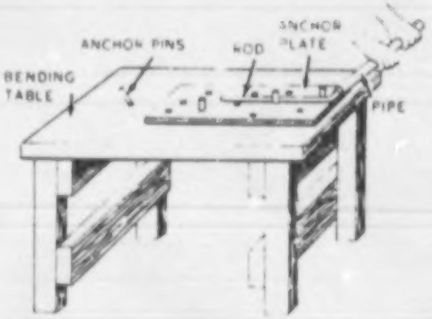

Figure 30. Bar-Bending Table

## SUMMARY

Steel is very strong; therefore, it is often used to reinforce concrete structures. Reinforcement steel is available in rods of various shapes and sizes, as well as wire mesh, both woven and welded. The selection of the type and amount of reinforcement needed depends on the structure and the strength required. The reinforcement used in walls is usually erected in place. The reinforcement used in slabs and columns may be assembled prior to installation. Wire, wooden blocks, stones, metal spacers and supports are used to position the reinforcement in the forms. To be able to cut, bend, and fabricate reinforcement steel, you will need to know how to use bending tables, shears, bolt and wire cutters, and pliers.

## QUESTIONS

1. Why is steel the best material for reinforcing concrete?
2. You have a reinforcement rod one inch in diameter. What is the bar number of this bar?
3. Name the three types of reinforcing materials.
4. Explain the purpose and application of reinforcement anchors.
5. Explain the method of bending steel reinforcing bars.
6. Why should all the loose scale be removed from steel reinforcement bars before they are used?
7. Name three things that are used to space and hold reinforcement materials.
8. What is used to space wire mesh in wall construction?

9. How far from the ground should steel reinforcement be placed in a concrete slab?

10. Name two types of reinforcing rods.

REFERENCES

AFM 85-4, Maintenance and Construction Methods for Buildings and Structures

CDC 55253, Masonry Specialist

## BUILDING FORMS FOR CONCRETE

### OBJECTIVE

This study guide provides you with the task-related information for you to be able to build forms for concrete walls.

### INTRODUCTION

Strong accurate forms are essential to good concrete construction. Concrete is a fluid mass that has to have something to harden in. If the forms are placed accurately and are strong enough, the end product will be of the proper shape and size to serve the purpose that the blueprints call for. But, if the forms are weak and improperly placed, the end product may not look anything like it's supposed to.

To make this study guide easier for you to understand, it is divided into the following main topics:

* CONCRETE BED PREPARATION
* DETERMINING REQUIREMENTS FOR FORM CONSTRUCTION
* FINAL INSPECTION OF FORMS

## CONCRETE BED PREPARATION

A good concrete job depends on the subgrade on which the concrete is laid. The soil must be compacted to eliminate the possibility of voids forming under the concrete. The voids will allow the concrete to settle and crack severely. A power tamp may be used to compact the soil. The power tamp is gasoline-engine powered and can compact the soil quickly.

A shovel and rake may be used to remove or add soil where required to level the bed or to bring it to its desired level.

The bed should be thoroughly wetted just prior to pouring the concrete. It should not be wetted enough to form water pools; however, wetting the subgrade aids in curing the concrete as it prevents the soil from absorbing the water from the concrete.

## DETERMINING REQUIREMENTS FOR FORM CONSTRUCTION

### Size and Shape of Forms

Both the size and shape of the forms may be determined from the blueprints and specifications.

### Strength of Form

Forms must be built to hold the weight of fresh concrete until the concrete hardens.

## Placement of Forms

Placement of the forms must be accurate. The accuracy of form placement can mean the difference between a building that is built correctly or one that is out of proportion.

The forms must follow the batter boards and line previously laid out from the structure blueprints.

## Wall Form Component

SHEATHING. Tongue and groove sheathing or plywood are the most common materials used to form watertight enclosures in which concrete may harden (figure 31-A).

Sheet metal masonite may be used as a liner on tongue and groove sheathing. The result will be a smooth surface on the hardened concrete.

STUDS. Concrete forms must be rigid to contain the fresh concrete in the desired shape until it hardens. Vertical support for the forms is provided by 2 x 4 studs as similarly adequate material (figure 31-B).

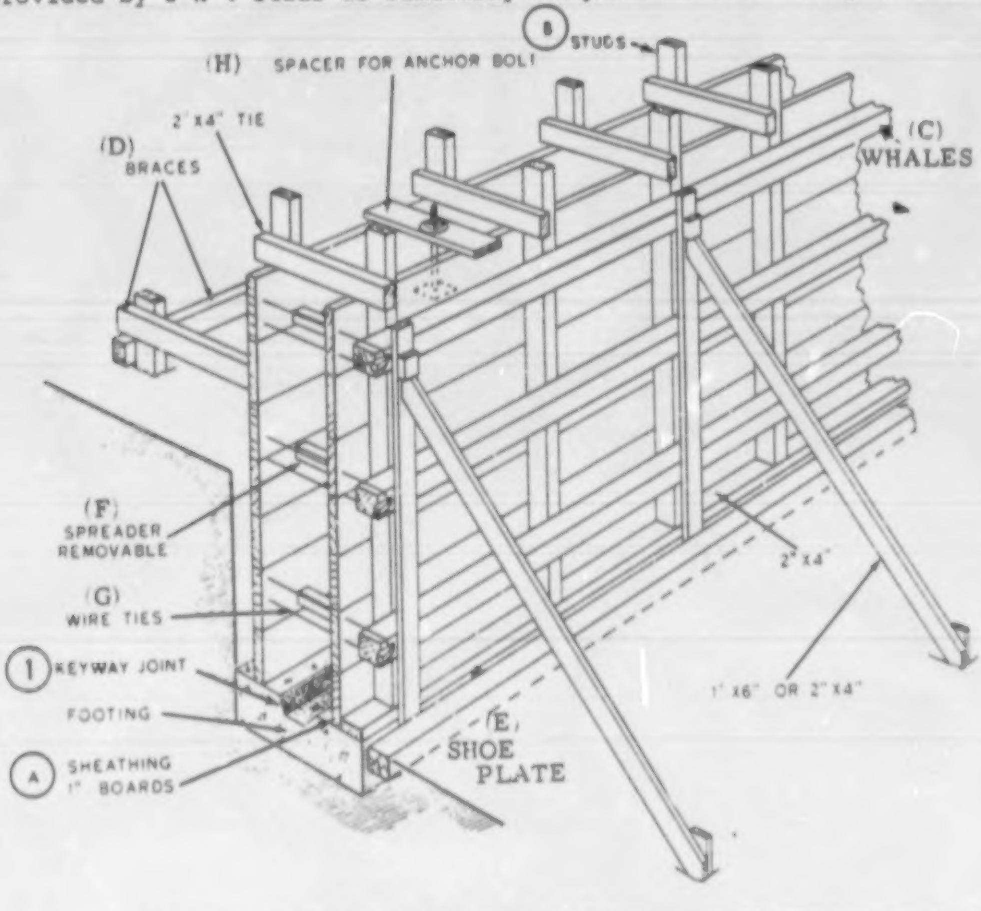
B STUDS
(H) SPACER FOR ANCHOR BOLT
2"x4" TIE
(D) BRACES
(C) WHALES
(F) SPREADER REMOVABLE
(G) WIRE TIES
I KEYWAY JOINT
FOOTING
A SHEATHING 1" BOARDS
(E) SHOE PLATE
2"x4"
1"x6" OR 2"x4"

Figure 31. Wood Wall Form

Construction Joints

Construction joints are used to separate areas of concrete placed at different times. A keyway construction joint is shown in figure 32 between a wall and a footing. If the wall and the footing are placed at the same time, a construction joint is not needed. The keyway construction joint is also shown in figure 33 in a vertical position. Note the beveled 2" x 4" used to form the keyway. This type of joint is generally used with reinforcing steel running from one section to the next. When reinforcing steel is not used, it is better to use a V-joint like that shown in figure 34. The V-joint is not as likely to break off as the keyway joint.

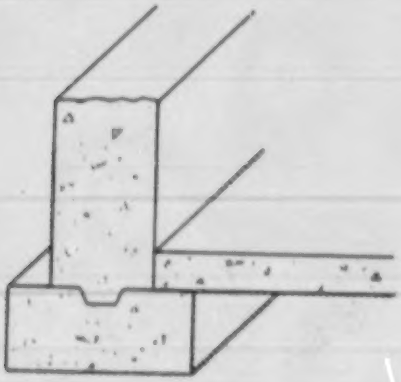

Figure 32. Keyway joint between a wall and footing.

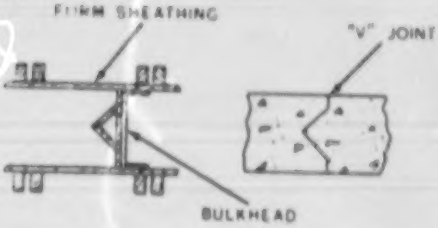

Figure 34. Top view of vertical V-joint for wall.

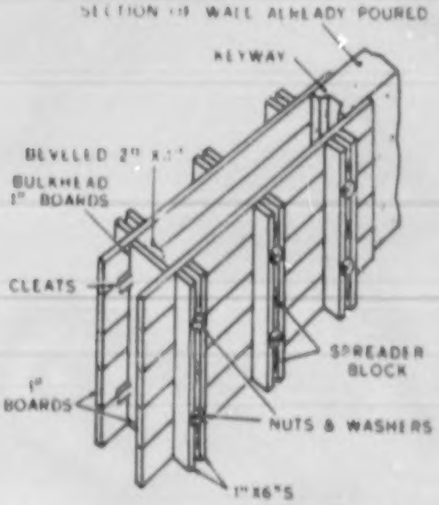

Figure 33. Vertical Keyway joint.

WALES. Studs also require reinforcing when they extend over 4 or 5 feet. This reinforcing is supplied by wales which tie prefabricated panels together and keep the forms in a straight line. They run horizontally and are lapped at the corners of the forms to add rigidity. They are usually made of the same material as the studs and are used in pairs with the long side projecting outward (figure 31-C).

BRACES. There are many types of braces which can be used to hold forms in place. The most common type is a member nailed from a stake to a stud or wale, at about a 30 degree angle to the horizontal (figure 31-D).

SHOE PLATE. The shoe plate is nailed into the foundation or footing and is placed carefully so as to give the correct wall dimensions. The studs are tied into the shoe and spaced accordingly (figure 31-E).

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SPREADERS. In order to maintain the proper distance between forms, small pieces of wood are cut to the same size as the thickness of the wall and are placed between the forms; these are called spreaders. When the concrete is placed in the form, enough pressure is applied on the form by plastic concrete to allow the spreaders to be removed (figure 31-F).

TIE WIRES. Tie wires hold the forms against the spreaders and keep the forms from spreading apart under the pressure of the fresh concrete. The wires run through the form and around both the wales and the studs. The wire is twisted in the center to draw the sheathing against the spreaders (figure 31-G).

Anchor Bolts

Anchor bolts are a very important part of a wall form. Anchor bolts are used to hold a building to the foundation wall.

The bolts are usually 1/2" to 3/4" in diameter and either "J" or "L" shaped and set at least 8" into the concrete.

They are usually spaced 1 foot from corners or door openings and at points where a wall changes direction. Spacing may be from 4 to 6 feet on center.

Template, a piece of wood with a hole drilled in it, is used to hold the bolt in place until the concrete has set sufficiently to support the bolt itself (figure 31-H).

Keyway joints are used to make a mechanical bond between wall and footing or adjoining wall (figure 31-I).

Sturdiness

The forms should be inspected for adequate bracing. Without substantial bracing, the forms will move when fresh concrete is placed in the forms.

Tight Joints

All joints should be inspected for security. Without tight joints, the forms may separate under the pressure of the concrete.

Proper Spacing

Forms are designed for a certain wall width and should be checked to insure proper measurements are met.

Oiling or Wetting of Forms

Oiling or wetting the forms serves two purposes. Wetting the forms provides a bond breaker between the forms and the concrete, or keeping the forms from sticking to the concrete as well as to keep the forms from absorbing water from the concrete.

Alinement

Forms should be checked for being level and square before the concrete is poured. Once the concrete is poured into the forms it is too late to make any changes to the forms.

SUMMARY

Strong forms are important to good construction. It is your responsibility to insure that the forms you pour are the best you can get. No matter how good the forms may look, it's better to waste a few minutes checking the forms than to loose hours repairing a broken form.

QUESTIONS

1. What determines the size of a form?
2. What are the purposes for oiling or wetting forms?
3. Why should the wall spacing be checked?
4. What is the purpose of anchor bolts?
5. What handtools do you use to prepare a subgrade?

REFERENCES

1. AFM 85-4, Maintenance and Construction Methods for Buildings and Structures
2. CDC 55253, Masonry Specialist

GP- 75-1090

# CONCRETING

## OBJECTIVE

Upon completion of this unit of instruction, you will be able to mix, place, finish, and cure a concrete slab.

## INTRODUCTION

The construction of a concrete structure on an Air Force installation requires the skill and knowledge of several Civil Engineering AFSCs. If the structure is a large one, it will be surveyed and staked off by Site Development personnel. Preparation of the subgrade and base course material for concrete slabs requires the efforts of both Pavements and Equipment Operator Specialists. The responsibility of building and placing forms, for wall or slab structures, lies with the Carpentry Specialist. None of these specialists, however, will be as involved, nor will they be as concerned, that the completed project be of high quality, as you, the mason.

To make certain that each phase of the project conforms to project specifications, you may be present when the site is surveyed and during subgrade and base course preparation. It is your duty and responsibility to advise carpenters during form construction and placement. Since the ultimate goal is a structure of good, strong, high-quality concrete, you will install reinforcing materials, determine the mixture ratio, order ready-mix or mix the proportioned ingredients yourself, and then transport, place, and finish the concrete slab form.

## PREPARING FOR CONCRETE PLACEMENT

### Inspection

One important step prior to concreting is to assure that all your equipment is operational and that your tools are in good condition.

The mixer should be checked to see that it is clean and in good operating condition. It should be serviced and lubricated prior to starting. Mixing blades should be checked for excessive wear, and the water batching mechanism should show no leakage when the valve is closed.

Before starting the concreting operation, we must be sure that the surface to receive the concrete, the forms, and the reinforcing materials are properly prepared. It only takes a few minutes to give these items one last check.

For concrete slabs, the subgrade, or base course, should be moistened to prevent the rapid extraction of water from the concrete and to aid in its curing. By sprinkling intermittently with water, the base upon which the concrete will be placed can be saturated without becoming muddy. The base should be free from sawdust, wood, nails, wire, pieces of metal, and other debris.

Forms should be tight and well-braced. They should be clean, properly oiled, and checked once more for proper dimensions.

## Installation of Joints

EXPANSION JOINTS. Concrete expands slightly when the temperature rises and contracts when the temperature falls. To relieve the forces resulting from the expansion of concrete, expansion joints are used. A nonextruding-type filler material should be used for expansion joints. This usually consists of a preformed bituminous or wood material 3/4-inch thick. The expansion joint should be designed so it will provide a complete and uniform separation between sections of the structure (figure 35). The expansion joint material should be cut to the correct size and ready for use before the concreting operation begins.

Expansion joints, for slab structures, should be constructed on the finished subgrade or base course before the mix is placed. These are the most difficult joints to set and maintain in their correct position, and should be checked throughout the paving operation. The expansion joint filler and dowels should be held securely in place with suitable installing devices (figure 36). The joint filler

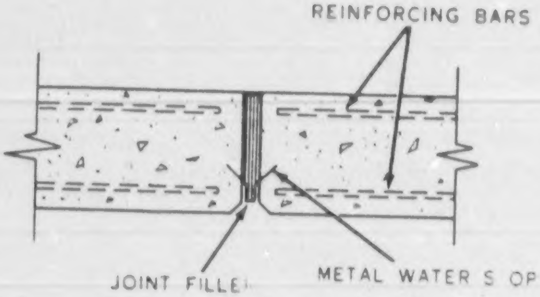

Figure 35. Expansion Joint for Wall, Top View

should be held in a vertical position and should be well-supported so that it will not be disturbed or damaged during concrete placement. The subgrade or base course should be well-prepared and the joint material should be cut accurately so that it will extend continuously from the required position at the top of the slab and from edge to edge of the pavement (figure 37).

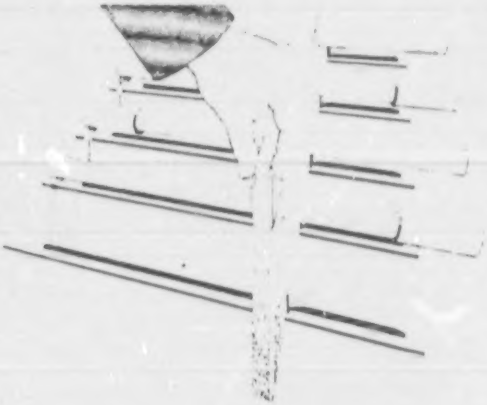

Figure 36. Placing Expansion Joint

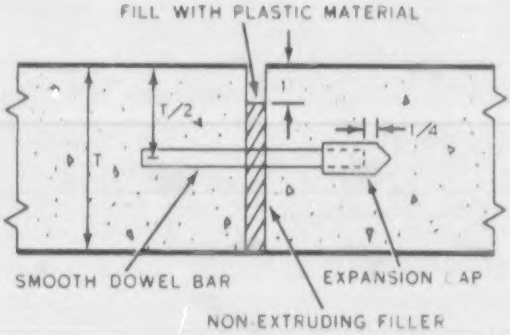

Figure 37. Expansion Joint in Concrete Slab Structure

CONTRACTION JOINTS. Contraction joints are used to control contraction cracking from temperature changes and the initial shrinkage of concrete. A contraction joint, sometimes called a dummy contraction joint, is shown in figure 38.

The joint is formed by cutting the slab with a concrete saw to a depth of one-third to one-fourth the slab thickness. This joint also gives some relief from expansion forces because the initial shrinkage of the concrete opens the joint slightly, cracking the concrete below the joint and providing room for expansion.

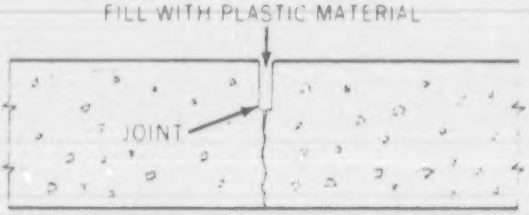

Figure 38. Contraction Joint

Selecting a Mixture Ratio

WATER-CEMENT RATIO. High-quality concrete depends upon the correct water-cement ratio (WCR). The WCR is the amount of water used per sack of cement. In other words, if good quality ingredients are proportioned correctly, the strength of cured concrete is determined by the amount of water added to the mixture per sack of cement in the mixture. From your work in Day 11, you learned that a standard 1-1-2-3 mix, using 6 gallons of water per bag of cement, has a WCR of 0.53. This simply means that for every bag of cement in the mixture, 6 gallons of water was added, or for every pound of cement, 0.53 of a pound of water was used. Table 4 gives the quantity of water to be used to attain concrete of a given strength.

SLUMP TEST. In Day 11, you mixed three separate batches of concrete and performed a slump test to determine the consistency of each batch. From these tests, you learned that the slump or consistency of concrete is governed primarily by the amount of aggregate in the mixture. A concrete mix with a fluid consistency flows easily into forms and around reinforcing materials. A stiff mix does not flow readily and usually requires additional labor or special equipment to place it. If more slump is needed, the mix can be adjusted by reducing the amount of sand and coarse aggregate, rather than by adding water.

| Gallons of water per sack of cement | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|
| Probable average 7-day strength in PSI | 4,400 | 3,500 | 2,800 | 2,200 | 1,800 |
| Probable average 28-day strength in PSI | 6,000 | 5,000 | 4,000 | 3,300 | 2,800 |

Table 4. Relationship between Gallons of Water Used per Sack of Cement and the Compressive Strength of Concrete

Changes in consistency of a given mixture are usually caused by changes in the aggregate, changes in the proportion of sand to gravel, or a change in the WCR. Slump tests should be made periodically to insure a uniform mixture throughout the concreting operation. To avoid mixes that are too stiff or fluid, slumps falling within the limits of Table 5 are recommended.

| Type of Construction | Slump in Inches | |
|---|---|---|
| | Maximum | Minimum |
| Reinforced foundation walls and footing . . . . . . . . . . . . | 5 | 2 |
| Plain footings, caissons, and substructure walls. . . . . . . | 4 | 1 |
| Slabs, beams and reinforced walls . . . . . . . . . . . . . | 6 | 3 |
| Building Columns. . . . . . . . | 6 | 3 |
| Pavements . . . . . . . . . . . . | 3 | 2 |
| Heavy mass construction . . . . | 3 | 1 |

Table 5. Recommended Slumps for Various Types of Construction

## MIXING, TRANSPORTING AND PLACING CONCRETE

### Mixing Concrete

Mixing is one of the most important steps in the production of high-quality concrete. For efficient production, a mixer should be used that will best meet the requirements of the project. Concrete may be mixed in a central plant which combines batching and mixing, or it may be mixed in a transit-mix truck. In the latter case, the proportioned ingredients are placed in the truck and mixed enroute to the site where it is placed in the forms. On large construction projects, concrete may be mixed in pavers at the site, and placed in the forms in one continuous operation. When transit-mix is being used, and the job is relatively small, a trailer-mounted mixer (figure 39) can be used.

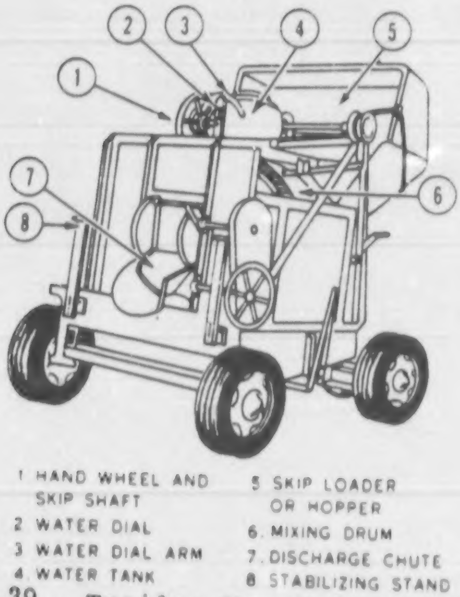
1
2
3
4
5
6
7
8
1 HAND WHEEL AND SKIP SHAFT
2 WATER DIAL
3 WATER DIAL ARM
4 WATER TANK
5 SKIP LOADER OR HOPPER
6 MIXING DRUM
7 DISCHARGE CHUTE
8 STABILIZING STAND

Figure 39. Trailer-Mounted Concrete Mixer

Regardless of the type of mixer used, the ingredients should be blended into a uniform mix, with all aggregate particles coated with cement paste.

### Transporting Concrete

After concrete leaves the mixer, it must be carefully handled and transported to prevent segregation. Segregation is the separation of aggregates from the mortar, or the separation of water from the rest of the mix. Improper handling and transporting can spoil the most carefully designed and properly mixed concrete. Segregation occurs because concrete is made from ingredients with different sizes and weights. If concrete is improperly transported, the coarse aggregate particles in the mix tend to settle to the bottom and the water rises to the top. This leaves voids in the concrete. These voids are called honeycombing or rock pockets.

The equipment used in handling and transporting concrete depends upon the size and type of job. On large jobs,

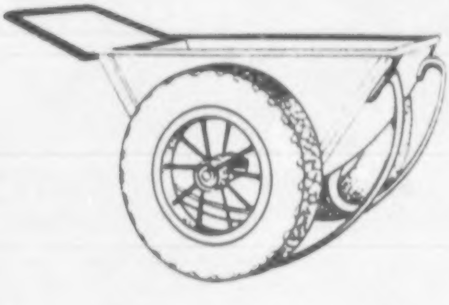

Figure 40. Rubber-Tired Buggy

ready-mix is normally used, and is deposited into the forms from the truck, when possible. For the usual small job, transporting by rubber-tired wheelbarrow or buggy (see figure 40) is the most economical method.

Placing Concrete

When concrete is placed in a slab, it should be started at the far end of the form, working back toward the source of the concrete. This method of concrete placement prevents your having to work over freshly placed mixtures. Each batch of concrete should be dumped against the previously placed batch and not away from it. When concrete is dumped in separate piles and worked, severe segregation of the concrete materials occurs.

When wheelbarrows or buggies are used to place concrete in slab forms, an efficient working arrangement is shown in figure 41.

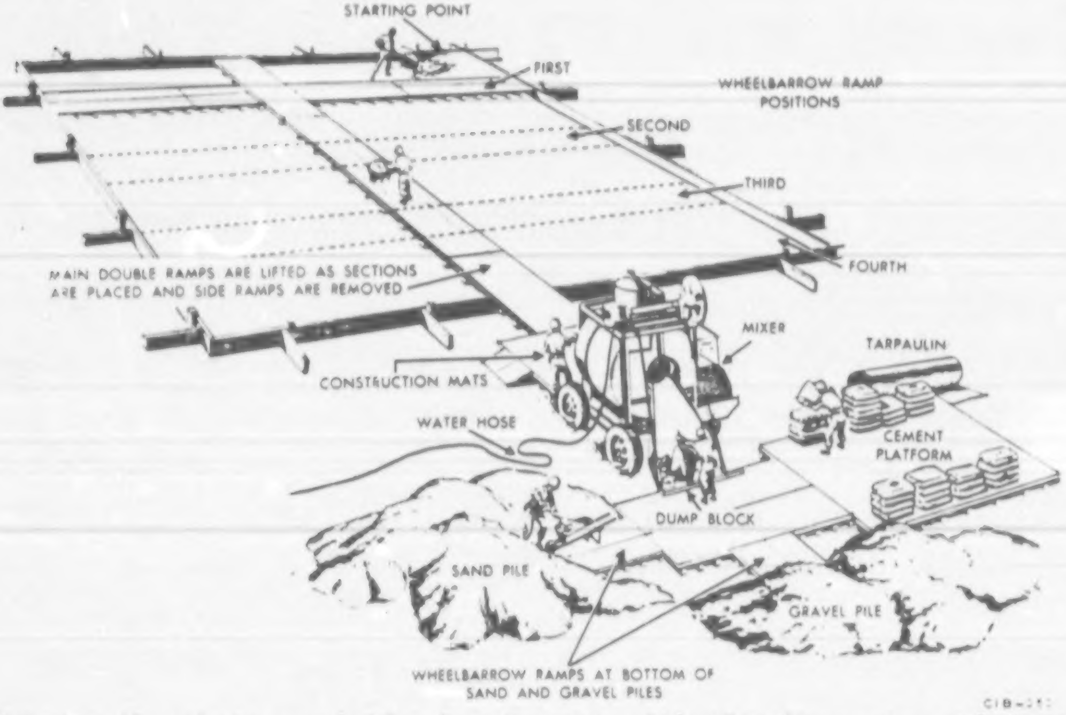
STARTING POINT
FIRST
WHEELBARROW RAMP POSITIONS
SECOND
THIRD
FOURTH
MAIN DOUBLE RAMPS ARE LIFTED AS SECTIONS ARE PLACED AND SIDE RAMPS ARE REMOVED
MIXER
TARPAULIN
CONSTRUCTION MATS
WATER HOSE
CEMENT PLATFORM
DUMP BLOCK
SAND PILE
GRAVEL PILE
WHEELBARROW RAMPS AT BOTTOM OF SAND AND GRAVEL PILES

Figure 41. Mixing and Placing Layout with Wheelbarrows and Buggies

## Consolidating

All concrete, with the exception of that placed under water, should be compacted and worked into place by spading, by puddling, or by mechanical vibrators. Compacting devices, such as spades or puddling sticks, long enough to reach the bottom of the form and thin enough to pass between the reinforcing material, should be used.

Consolidation eliminates rock pockets and large air bubbles and brings enough fine material to the surface to produce the desired finish. In the process of consolidation, you should carefully work the concrete around the reinforcing steel to assure proper embedding of the steel in the concrete. When consolidating, try to avoid displacing the reinforcing steel because the strength of the concrete structure depends on its proper location.

Concrete can be effectively consolidated by using mechanical vibrators. With vibration, it is possible to place mixtures too stiff to be placed by hand. Stiff concrete mixes require less cement and are more economical. There is also less danger of segregation in this type of mix. The mix should never be so stiff that an excessive amount of labor is required to place it.

The internal vibrator involves insertion of a vibrating element into the concrete. The external type is applied to the forms. They are powered by electric motor, gasoline engine, or compressed air.

The internal vibrator should be inserted in the concrete in a vertical position, at intervals of approximately 18 inches to allow some overlap of the approximately 18 inches to allow some overlap of the area vibrated at each insertion. It should also pass through several inches of the previous layer to insure a good bond between layers.

You will know that sufficient vibration has taken place when a thin line of mortar appears along the form. When you are using an internal vibrator, as shown in figure 42, be careful not to let it contact the forms because the vibrator could damage them. Mixes that are not too stiff and can be consolidated by spading or puddling should not be vibrated because vibration of this type mix could cause segregation.

External vibrators are rigidly attached to the forms by means of a clamp or vise. Part of the energy of the form vibrator is absorbed by the forms, because the vibratory action must be transmitted through the forms to the concrete. Form vibrators should not be placed farther apart than the radius through which the vibration is visibly effective.

You should raise the vibrators as the forms are filled but keep them below the level of the concrete. The distance on the form below the level of the concrete at which the vibrator is placed depends on the consistency and thickness of the concrete.

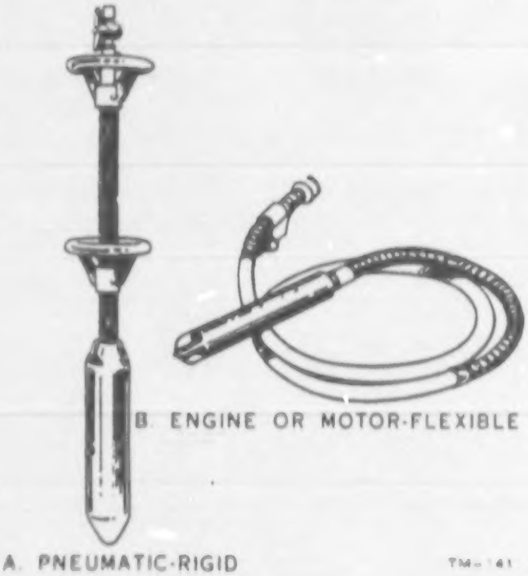

Figure 42. Rigid and Flexible Shaft Internal Vibrators

As with internal vibrators, sufficient vibration has taken place when a thin line of mortar appears on the edge of the form. After the concrete has been properly vibrated, you should immediately start the finishing operation before the concrete starts to set.

## Finishing Concrete

After a floor slab, sidewalk, etc., has been placed, the top surface is rarely at the exact elevation desired. The process of striking off the excess concrete, to bring the surface to the proper elevation, is called screeding. In this operation, a templet or a straightedge (a 2 x 4 or 2 x 6 board with a straight edge) is moved back and forth across the concrete with a sawing motion, as shown in figure 43.

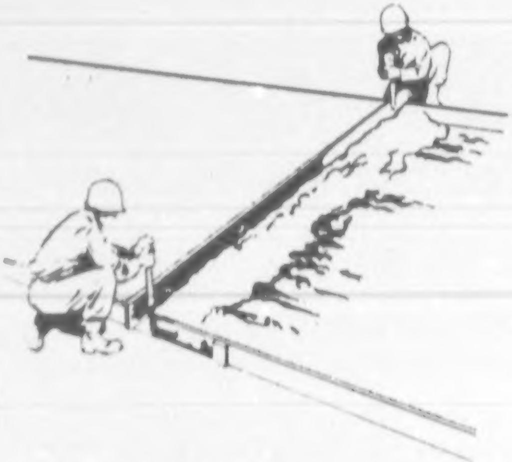

Figure 43. Screeding Operatior

The templet rides on wood or metal forms that are used as guides. With each sawing motion, the templet is moved forward a short distance. You should always keep a small amount of concrete ahead of the templet to fill in low spots and maintain a level surface as the templet is moved forward. If there is a tendency for the templet to tear the concrete surface, the rate of forward movement should be reduced or the bottom edge of the templet covered with metal.

In most cases, just slowing the templet will stop the tearing action. You will encounter this tearing problem when you use air-entrained concrete (because of its sticky nature). After the concrete is struck off, a hand tamper, better known as a jitterbug, can be used to further compact the concrete into a dense mass. A hand tamper, or jitterbug, is shown in figure 44. Now that the concrete is leveled off and tamped, it may be necessary to float, trowel, broom, or rub the surface, depending on the finish desired.

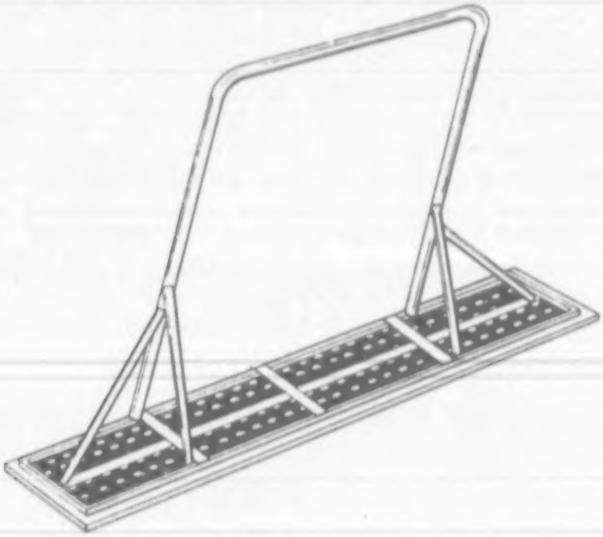

Figure 44. Hand Tamper or Jitterbug

If a smoother surface is required than one obtained by screeding, the surface should be worked sparingly with a wood or metal float or a finishing machine. Figures 45, 46, 47, and 48 illustrate a wood float, a long-handled wood float, a steel trowel and edger, and a typical power trowel for finishing concrete.

The floating process should take place shortly after screeding and while the concrete is still plastic and workable. You should eliminate high spots, fill in low spots, and at the same time bring sufficient mortar to the surface to produce the desired finish.

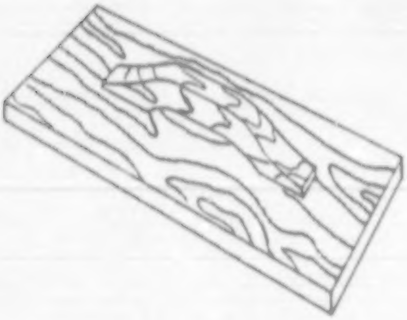

Figure 45. Wood Float

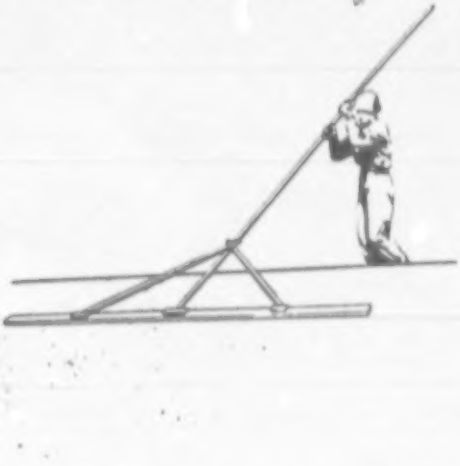

Figure 46. Long-Handled Wood Float

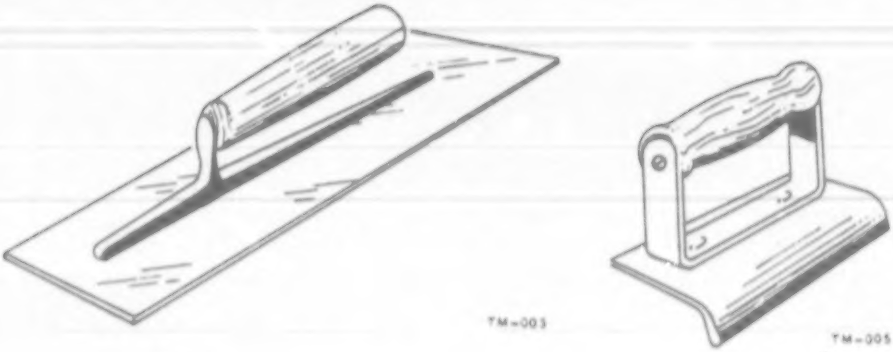

Figure 47. Steel Trowel and Edger

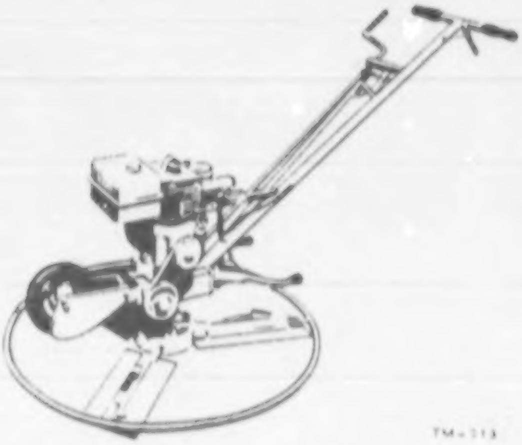

Figure 48. A Typical Power Trowel

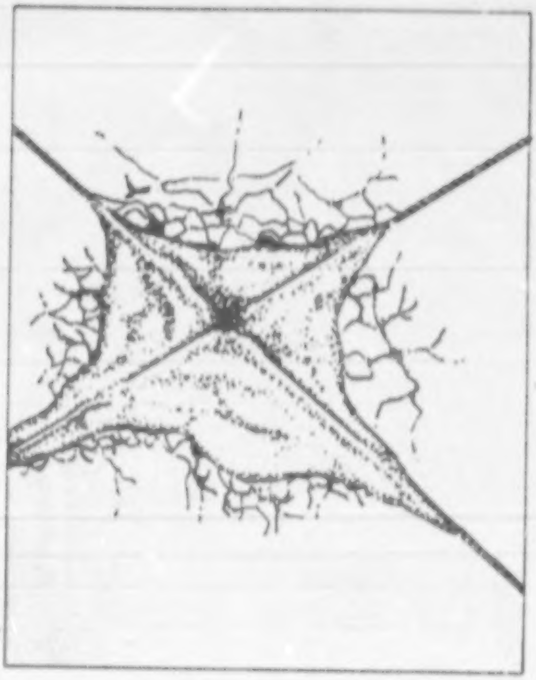

Figure 49. Scaling Due to Overfinishing

Do not overwork the concrete while it is still plastic, because this will bring an excess of water and mortar to the surface. A mixture of water and mortar will form a thin, weak layer which will scale or wear off under usage, as shown in figure 49. Where a coarse finish is desired (as the final finish), you should float the surface a second time after it has partially hardened.

When working on large concrete slabs, use a long-handled wood float, as shown in figure 46. Before we go any further with the finishing operation, let's edge and joint the concrete before it becomes too stiff.

Where edging is necessary, it should be done immediately after the floating and before the concrete has stiffened too much. Edging will give you a rounded edge that will prevent chipping or damage to the concrete slab.

You should run the edger back and forth between the concrete and the form until a finished edge is produced. You should be very careful that all coarse aggregate particles are covered and that the edge does not leave too deep an impression in the surface of the slab. Too deep an impression in the top of the slab may be difficult to remove with the final finishing operations. An edger was shown in figure 47.

Now that we have edged the concrete, the next step is to joint (groove) the slab. The cutting edge or bit of the jointer tool cuts joints in the slab called contraction joints. In sidewalks and driveways, contraction joints should be spaced at intervals equal to the width of the slab, but never more than 20-foot intervals. It's a good practice to use a straight board as a guide when you are cutting joints in the concrete. On large surfaces, joints can be cut with an electric or a gasoline-driven power saw.

Joints made with a power saw should be cut within 4 to 12 hours after the slab has been placed and finished. A jointer or groover is shown in figure 50. Now that the slab is edged and jointed, let's continue with the different finishes for concrete surface.

If a dense, smooth surface is desired, floating should be followed by steel troweling. Steel troweling operations are shown in figure 51. You should perform this troweling operation after the moisture film or shine disappears from the floated surface and the concrete has hardened enough to prevent the fine material and water from working to the surface.

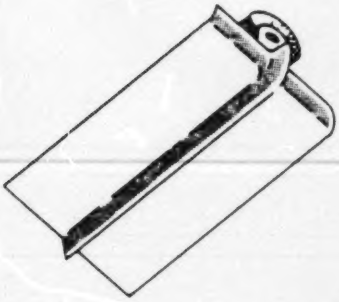

Figure 50. Jointer or Groover

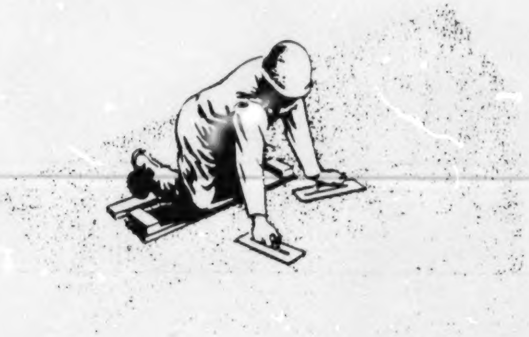

Figure 51. Troweling Operation

Excessive and too-early troweling tend to produce crazing (breaking into pieces) and lack of durability; too long a delay in troweling results in a surface that is too hard to finish properly. The usual tendency is to start to trowel too soon. Troweling should leave the surface smooth, even, and free of marks and ripples.

Spreading dry cement on a wet surface to take up the excess water is not a good practice if a wear-resistance and durable surface is required. If excess water is present on the surface of the slab, finishing operations should be delayed until the water has evaporated or been carefully blotted up.

To obtain a surface that is fine-textured but not slippery, you should trowel over the surface with a circular motion immediately after the first regular troweling. In this process, you should keep the trowel flat on the surface of the concrete.

Where a hard, steel-troweled finish is required, the first regular troweling should be followed by a second troweling after the concrete has become so hard that no mortar adheres to the trowel and a ringing sound is produced as the trowel is passed over the surface.

When you are giving the surface a final troweling, you should hold the trowel in a slighly tilted position and apply heavy pressure so that the surface is thoroughly compacted.

Hairline cracks in a slab are usually caused by a concentration of water and fines at the surface, resulting from overworking the concrete during finishing. Rapid drying will also cause cracking. Voids that develop prior to troweling usually can be closed by pounding the concrete with a hand float.

If a nonskid surface is desired, it can be produced by brooming the concrete before it has thoroughly hardened. You should carry out the brooming operation immediately after the slab has been floated. For some floors and sidewalks where severe scoring is not desirable, the broomed finish can be produced with a hairbrush (paint brush) after the surface has been troweled to a smooth finish.

Where rough scoring is required, use a stiff broom made of steel wire or some type of coarse fiber. Always broom the concrete in such a manner that the direction of the scoring is at a right angle to the direction of traffic.

Another method of producing a nonskid surface is to drag a wet burlap belt longitudinally along the length of the strip (figure 52). The burlap must be clean and kept well saturated. After the desired finish is obtained, the curing operation should be started immediately.

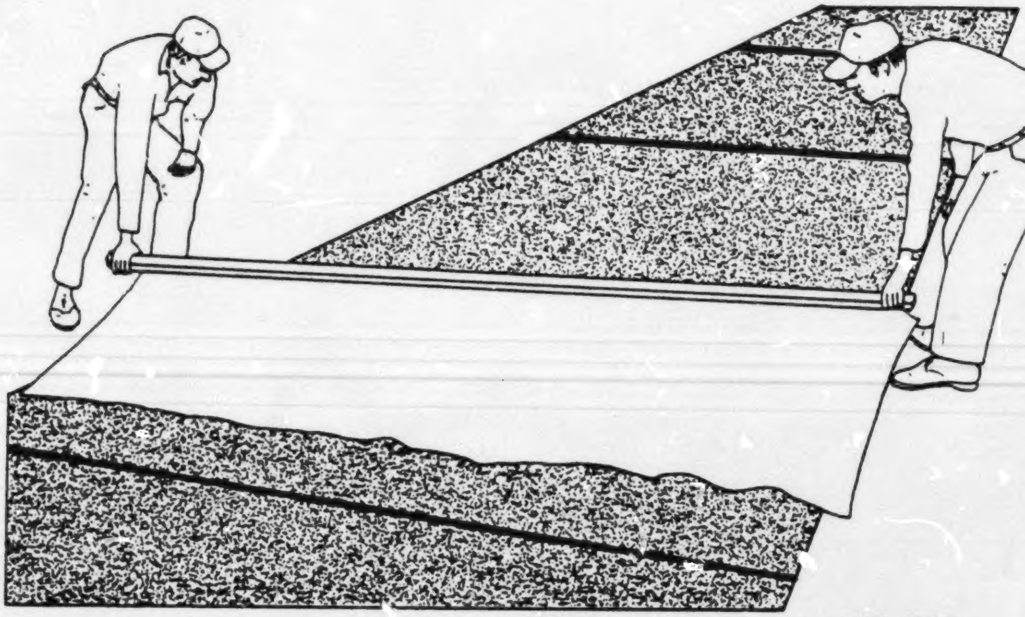

Figure 52. Burlap Drag

## SPECIAL PROCESSES

### Cold Weather Concreting

Unfortunately, the weather plays an important role in the making of good concrete. In cold weather, concrete hardens slowly and is subject to freezing which will result in a poor concrete job. In hot weather it sets too fast and fine hairline cracks will develop, weakening the concrete structure.

Concrete placed when the air temperature is less than 50°F. is classified as cold weather concrete, and certain precautions are necessary for cold weather concreting. Concrete hardens slowly and gains strength slowly at low temperatures. If the concrete freezes during the first 2 days after placing, it will be severely damaged.

Never place concrete on a frozen subgrade because of the danger of settling when the ground thaws. Before placing concrete in forms, remove all ice, snow, and frost from the forms and reinforcing material. This task can be efficiently accomplished by using live steam.

If protective covering is required, it should be installed as completely as possible before the concrete is placed. After the concrete is placed, the remainder of the covering should completely inclose the freshly placed concrete to minimize heat loss. If warm concrete is to be placed on a cold surface of hardened concrete, the hardened concrete must be warmed and its surface sufficiently moistened before the new concrete is deposited.

For air temperatures of 40° to 50°F., the temperature of the placed concrete should be from 60° to 70°F. A placed concrete mix of 60° to 70°F. can be produced by heating the mixing water and aggregate, if necessary, to a temperature between 70° and 80°F. when it is placed in the mixer.

For permanent construction, the placed concrete must be cured at a temperature of 50°F. for 5 days or 70°F. for 3 days. If high-early-strength cement is used, the curing period can be reduced to 2 days at 70°F. or 3 days at 50°F.

For air temperatures from 32° to 40°F., high-early-strength cement should be used, or 2 pounds of calcium chloride per sack of cement should be added to accelerate hardening. The forms may have to be heated to remove any ice, snow or frost. The concrete temperature at the time of mixing should be from 70° to 80°F. This temperature can be obtained by heating the water or heating both the water and aggregate. In no case should the concrete mixing temperature exceed 80°F.; higher temperatures will reduce its strength. Remember, the curing conditions described in the previous classification must be provided.

For air temperatures in the 0° to 32°F. range, high-early-strength cement should be used; however, if this type of cement is not available, calcium chloride should be added in the amount of no more than 2 pounds per sack of ordinary cement. Calcium chloride is an accelerator which enables the concrete to develop strength more rapidly.

The aggregate and water must be heated to provide 70° to 80°F. concrete temperature at the mixer. It is also advisable to heat the forms. Curing conditions as described in the first classification must be provided. After the required curing period, the concrete can be allowed to cool to the temperature of the atmosphere, regardless of how cold it is. Never attempt to place concrete in temperatures below 0°F. unless the amount of concrete is exceptionally small and can be easily protected.

If concrete is frozen before it has taken its initial set, it will not be damaged if thawed out rapidly and properly. It will later develop almost the same strength and durability as it would have if freezing had not occurred. Rapid thawing is done with the use of heated inclosures.

The freezing of concrete before it sets up will cause the water to expand and disrupt the bond between the cement and aggregate particles. If the freezing occurs after the concrete has set up and after it has been cured as required, there will be no damage.

Heating the mixing water is the most practical means of warming the concrete. Water is not only easy to heat, but each pound of water heated to a given temperature has roughly five times as many heat units stored in it as are stored in a pound of aggregate at the same temperature.

Water is commonly heated in a boiler by live steam or by heating coils. The temperature of water should never exceed 165°F. because of the danger of causing a quick flash set of the cement. Mix the hot water with the aggregate so the mix temperature will be below 80°F. before you put in the cement. Take care so that the hot water does not come immediately into contact with the cement.

## Hot Weather Concreting

During hot weather, precautions should be taken to maintain concrete temperature during curing at not more than 85° to 90°F. There will be climatic conditions where this limitation cannot be observed.

Mixing, placing, and curing concrete at high temperatures affects it in three different ways: (1) the strength of concrete that is mixed and cured at high temperatures is never as great as that of concrete mixed and cured at moderate temperatures, (2) the cracking tendencies are increased because of the greater range between the high temperature at the time of hardening and the low temperature to which the concrete will later drop, and (3) concrete which is mixed, placed, and cured at high temperatures has been found to fail sooner, as a result of repeated cycles of moisture and temperature changes above the freezing point, than concrete which is mixed, placed, and cured at moderate temperatures.

The temperature of a concrete mix can be lowered by any of several means. These means include: (1) using cold mixing water (slush ice can be used in extreme cases to cool the water), (2) avoiding the use of hot cement, (3) cooling the coarse aggregate by sprinkling, (4) insulating mixer drums by cooling them with sprays or wet burlap coverings, (5) insulating water supply lines and tanks, (6) shading materials and facilities not otherwise protected from the heat, and (7) by working only at night.

Concrete curing is difficult to accomplish in hot weather because the water evaporates rapidly. However, it is especially important to protect concrete in hot weather because of the greater danger of crazing and cracking from rapid loss of moisture. Therefore, moist curing, especially ponding, should be used.

## SUMMARY

Good quality concrete must have the correct proportion of properly mixed ingredients. However, this is only the starting point. Poor transporting and handling practices can ruin the most carefully measured and properly mixed. Several means of transporting concrete are available. Transit-mix trucks usually are used to deliver concrete to large construction sites. On smaller jobs, wheelbarrows or buggies may be used. The means of transportation requires careful planning and, at times, must be used in conjunction with chutes to place concrete. Chutes must be sloped correctly, and if the distance concrete must travel through a chute is too far, it will dry out or segregate.

The quality of concrete can be improved with the use of vibrators to consolidate it during the placing operation.

After concrete is placed in forms, it is finished by screeding; tamping, if required; floating while the concrete is still plastic; edging, if necessary; then jointing or grooving.

Changes in temperature will cause concrete to expand and contract. This action may result in cracking or buckling of the concrete. To relieve this condition, expansion joints are installed.

There are special processes for concreting due to cold and hot weather.

QUESTIONS

1. Why is it good practice to oil concrete forms?
2. How can the base for a concrete slab be saturated and not become muddy?
3. What could be the result of overfinishing concrete?
4. Explain how you would check the consistency of a concrete mixture?
5. When are expansion joints placed in concrete mixtures?
6. What is meant by screeding?
7. What is a jitterbug?
8. What chemical is used to accelerate hardening?

REFERENCES

CDC 55233, Masonry Specialist

# MIXING AND PLACING CONCRETE FOR WALL STRUCTURES

## OBJECTIVE

Upon completion of this unit of instruction, you will be able to mix, place, and finish concrete in a wall form.

## INTRODUCTION

Prior to placing concrete in a wall form, you must complete the construction of the foundation and forms and install the reinforcing material. An inspection of the forms and reinforcement steel should be accomplished before you start placing the concrete. The methods and techniques of placing concrete in wall forms are similar to those used in placing concrete in a slab form.

## CONCRETE MIXTURE

Concrete to be placed in a wall must be of a consistency that can be worked around the steel reinforcement bars. Concrete containing large aggregate particles with a stiff consistency is not suitable for use in thin walls or walls with reinforcing bars. The adequate consistency can be determined by performing the slump test. The reccommended slump for reinforced walls is from 5 to 2 inches. A mixture of concrete which has a slump of 3 to 4 inches may be obtained by using the standard mix ratio 1 : 2 : 3, cement : sand : gravel, with six gallons of water per sack of cement. This ratio is based upon volume. The maximum size aggregate is one inch. The consistency is adjusted by varying the amount of aggregate. The water - cement ratio should be dept constant.

### Handling and Transportation

After concrete leaves the mixer, it must be carefully handled and transported to prevent the aggregate separating from the mortar or the water from other ingredients. Improper handling and transporting can spoil the most carefully designed and properly mixed concrete. Separation or segregation occurs because concrete consists of materials of different sizes and weights.

The equipment used in handling and transporting concrete depends on the size and type of job. If ready-mix concrete is used, the concrete should be deposited in the forms straight from the truck, if possible. For the usual small job requiring no high lifts, transporting by wheelbarrow or buggy is the most economical method. Sometimes chutes must be employed in conjunction with the wheelbarrow and buggy in order to place the concrete properly in the forms. Stiff mixes require chutes to be placed on steeper slopes. Specially designed buckets are used to move concrete above and below the mixer. The lifting is done by a crane. If the concrete is to be deposited below or about the same level as the mixer, a simple arrangement of 2-inch thick plank runways placed on the ground can be used for the buggy to ride on. If the difference in level is large, then a drop chute, like the one shown in figure 53 should be used.

Concrete can be allowed to drop freely, without a chute, for a maximum of 5 feet, when being dropped in forms and 3 feet for exposed work. When concrete is to be elevated above the mixing level, less than 15 feet above ground, inclined runways for transporting the concrete to the required elevation can be built at low cost.

For short distances, chutes can be used for transporting concrete. You should never transport concrete for long distances, it tends to dry out and segregate. For the usual concrete mix, the slope of the chute should be from 2 to 3 feet horizintal to 1 foot vertical. If you are working with a stiff mix, a steeper slope should be used. A down pipe should be provided at the end of the chute so that concrete will drop vertically and not segregate.

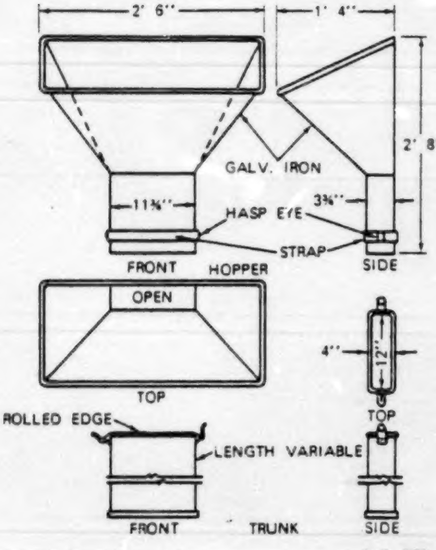

Figure 53. Concrete Drop Chute

## Placing Concrete

After the forms are set and the reinforcement materials installed, you are ready to concrete. The actual concreting operation consists of placing the concrete in the forms and consolidating, finishing, and curing it.

When placing concrete in high walls, you should deposit it in level layers, not more than 12 inches deep. Each level should be spaded just enough to make the concrete settle thoroughly and produce a dense mass before the next layer is placed.

If you should have to stop placing concrete in the wall for a long period of time, or at the end of the day's work, you should roughen the top surface of the wall just before it hardens. This will provide a good bond for the next layer of concrete. Before starting to place concrete again, you should clean the roughened surface and apply a thick creamy coat of cement-water paste with a brush just ahead of the freshly placed concrete. This will give you a good bond between the different layers of concrete and also enable the wall to be watertight.

After the concrete wall has been placed, the top surface is rarely at the exact elevation desired. The process of striking of the excess concrete, to bring the surface to the proper elevation, is called screeding. In this operation, a templet or a straight edge is moved back and forth across the concrete with a sawing motion. If a smoother surface is required than one obtained by screeding, the surface should be worked sparingly with a wood or metal float or a finishing machine.

## Anchor Bolts

Buildings are anchored to masonry walls to prevent them from shifting from the wall. This shifting may be caused by excessive winds which tend to lift the structure mounted on the walls. Anchor bolts are positioned in the form work prior to placing the concrete. One of the most common type anchor is a threaded rod with a nut and washer on one end. The other end is bent to hold in the concrete.

Another type is a thread rod with an attached flang on the end which will be in the concrete. The threaded end of the bolts should extend above the top of the concrete far enough to extend through a plate and receive a nut.

## SUMMARY

To properly place concrete in a wall form, the concrete must be adequately mixed and have the proper consistency. Transportation and handling is just as important as having a good mix. Poor handling can cause separation of the ingredients. Chutes may be used to place the concrete at the required location. Concrete should not be deposited in greater than 12 inch levels without spading. Concrete can be leveled by screeding. Anchor bolts are installed in concrete to hold or support other structures.

## QUESTIONS

1. What is the purpose of chutes? ______________________________
   ______________________________.
2. What should the slope of a chute be for a fluid concrete? ______________________________
   ______________________________
   For stiff concrete? ______________________________
3. How do you check the consistency of a concrete mix? ______________________________
   ______________________________.
4. What is the purpose of roughening the top surface of a concrete wall at the end of a day's work? ______________________________
   ______________________________.
5. How is a concrete wall finished? ______________________________
   ______________________________.

# CURING CONCRETE

## OBJECTIVE

This study guide will provide you with the knowledge necessary to effect a satisfactory cure of concrete slabs and structures.

## INTRODUCTION

Although concrete is one of the most useful building materials developed by man. it requires much care immediately after initial placement. This care we will call curing. Initial concrete curing performs two important functions in concrete. (1) Prevents loss of moisture, insuring water availabe to complete hydration process in concrete; and (2) maintains temperature level to insure this complete chemical reaction. This study guide will describe the curing operation and different methods used in curing concrete.

## Curing - General

Concrete should be cured by protection against rapid loss of moisture and rapid temperature changes for a period of not less than 7 days from the beginning of the curing operation. Unhardened concrete should be protected from rain and flowing water. All equipment needed for adequate curing and protection of the concrete should be on hand and ready to install before actual concrete placement begins. In all cases in which the curing medium requires the use of water, the curing should have prior right to all water supply or supplies. Protection should be provided as necessary to prevent cracking of the pavement caused by temperature changes during the curing period. The sides of concrete slabs exposed by the removal of forms should be protected within 1 hour after removal of forms to provide the exposed surfaces with continuous curing treatment equal to that provided by the method selected for curing the slab surface, and to prevent injury to the pavement edge and the underlying subgrade. Covering material should not be used that contains or becomes contaminated with sugar in any form, tannic acid, or any other substance detrimental to portland cement concrete. Any covering material such as mats, waterproof paper, or impermeable sheets used in curing should be removed as necessary for testing the surface, correcting deficiencies, and sawing joints. The concrete surface should be maintained wet with a water spray until the covering materials are replaced. Where membrane curing is used, all damaged areas should be resprayed with curing compound immediately upon completion of testing and any required surface correction.

## Initial Curing

Immediately after the finishing operations have been completed and the concrete has set sufficiently to prevent marring the surface, the forms and entire surface of the newly laid concrete should be covered with wetted burlap or cotton mats as discussed below. The initial moist curing shall be continued for a period of not less than 24 hours. The surface of the newly laid concrete should be kept moist and damp until the burlap or cotton-mat coverings are in place.

Final Curing

Curing of the concrete should be continued for the duration of the required curing period by any of the methods described below.

BURLAP OR COTTON-MAT CURING. The coverings may be either burlap or cotton mats. Burlap covers should consist of two or more layers of burlap having a combined weight of 14 ounces or more per square yard in a dry condition. Burlap should either be new or have been used only for curing concrete. Cotton mats and burlap strips should have a length, after shrinkage, at least 1 foot greater than necessary to cover the entire width and edges of the pavement lane. The mats should be thoroughly wetted before placing and kept continuously wet and in intimate contact with the pavement edges and surface for the duration of the required curing period.

WATERPROOF-PAPER BLANKETS OR IMPERMEABLE SHEETS. Immediately after removing the covering used for initial curing, the surface of the concrete should be wetted with a fine spray of water and then covered with waterproof-paper blankets, polyethylene coated burlap blankets or polyethylene sheets (if available). The burlap of the polyethylene coated burlap should be thoroughly saturated with water before placing. The waterproof-paper blankets, polyethylene coated burlap blankets, or polyethylene sheeting should be in pieces large enough to cover the entire width and edges of the slab. (Polyethylene sheets carefully lapped will eliminate the necessity for two curing treatments. This material is also lighter, cheaper, and more easily handled than polyethylene coated burlap.) The sheets should be placed with the light-colored side up. Adjacent sheets should overlap not less than 12 inches with the lapped edges securely weighted down and cemented or taped to form a continuous cover and a completely closed joint. These coverings should be adequately weighted down to prevent displacement or billowing from winds. Covering should be folded down over the side of the pavement edges and secured by a continuous bank of earth or other approved means. Tears and holes appearing in coverings during the curing period must be patched immediately. The coverings should remain in place during the entire specified curing period.

MEMBRANE CURING. Immediately after removing the wet covering used for initial curing, the entire exposed surface of the concrete should be uniformly coated with a membrane curing compound (figure 54). The concrete should not be allowed to dry out before the application of membrane. If any drying has occurred, the surface of the concrete should be moistened with a spray of water.

The curing compound should be applied to the finished surfaces by means of an approved automatic spraying machine as soon as the free water has disappeared (if available). The spraying machine should be self-propelled and ride on the side forms or previously constructed pavement, straddling the newly paved lane. The machine should be equipped with spraying nozzle or nozzles that can be so controlled and operated as to completely and uniformly cover the pavement surface with the required amount of curing compound. The curing compound in the storage drum used for the spraying operation should be thoroughly and continuously agitated mechanically throughout the full depth of the drum during the application. Air agitation may be used only to supplement mechanical agitation. Spraying pressure should be sufficient to produce a fine spray and cover the surface thoroughly and completely with a uniform film. Spray equipment should be maintained in first-class mechanical condition and the spray nozzle should be provided with an adequate wind guard. The curing compound should be applied with an overlapping coverage that will give a two-coat application at a coverage of not more than 200 square feet per gallon for both coats.

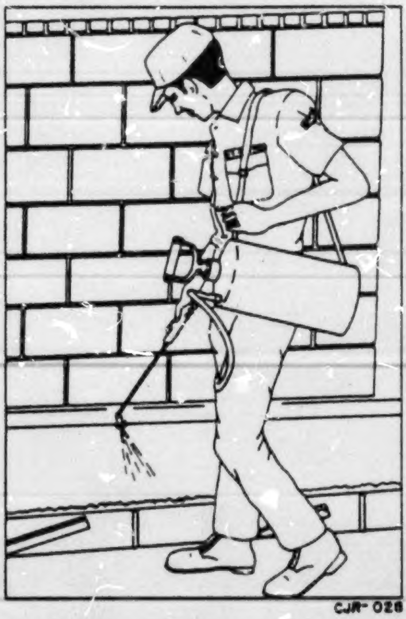

Figure 54. Application of Curing Compound

The application of curing compound by hand-operated pressure sprayers is satisfactory only on odd widths or shapes of slabs and on concrete surfaces exposed by the removal of forms, as authorized. When application is made by hand-operated sprayers, the second coat should be applied in a direction approximately at right angles to the direction of the first coat. The compound should form a uniform, continuous, cohesive film that will not check, crack, or peel, and that will be free from pinholes and other imperfections. If discontinuities, pinholes, or abrasions exist, an additional coat should be applied to the affected areas within 30 minutes. Concrete surfaces that are subjected to heavy rainfall within 3 hours after the curing compound has been applied should be resprayed.

Necessary precautions should be taken to assure that the concrete is properly cured at the joints, but that no curing compound enters the joints that are to be sealed with joint-sealing compounds. The top of the joint opening and the joint groove at exposed edges should be tightly sealed as soon as the joint-sawing operations have been completed. After application of the seal, the concrete in the region of the joint should be sprayed with curing compound. The method used for sealing the joint groove should be effective in preventing loss of moisture from the joint during the entire specified curing period.

Approved standby facilities for curing concrete pavement should be provided at a location readily accessible to the site of the work. These would be for use in the event of mechanical failure of the spraying equipment or any other conditions that might prevent correct application of the membrane-curing compound at the proper time.

Concrete surfaces to which membrane curing compounds have been applied should be adequately protected for the duration of the entire curing period from pedestrian and vehicular traffic, except as required for joint-sawing operations and surface tests, and from any other possible damage to the continuity of the membrane. Any area covered with curing compound that is damaged by subsequent construction operations within the curing period must be resprayed.

Curing concrete may be done in one of the following methods:

- Burlap, wetted
- Cotton mats, wetted
- Damp straw
- Tarpaulin
- Continuous water spray
- Waterproof paper
- Polyethylene sheets
- Membrane curing compound

## SMOOTHNESS TEST

The finished surfaces of airfield pavements shall have no abrupt change of 1/8 inch or more and shall not deviate from the testing edge of an approved 12-foot straightedge more than 1/8-inch longitudinally and 3/16-inch transversely.

High areas of unsatisfactory smoothness shall be reduced either by rubbing the freshly finished concrete with a Carborundum brick and water when the concrete is less than 36 hours old or by grinding the hardened concrete with an approved surface-grinding machine after the concrete is 14 days or more old. Rubbing with Carborundum brick shall be discontinued as soon as contact with coarse aggregate is made. All further necessary reduction shall be accomplished by grinding the hardened concrete with an approved surface-grinding machine.

## COLD WEATHER CONCRETING

Concrete placed when the air temperature is less than 50°F is classified as cold-weather concrete. Precautions are necessary for cold-weather concreting, since concrete hardens slowly and gains strength slowly at low temperatures. If the concrete freezes during the first 2 days after placing, it will be severely damaged. Concrete should never be placed on a frozen subgrade because of the danger of settling when the ground thaws. Before placing the concrete, all ice, snow, and frost must be removed from the forms and reinforcement; this is efficiently done with live steam. If protective covering is required, it should be partially installed before the concrete is placed. After the concrete is placed, the covering should completely surround the concrete to minimize heat loss. If warm concrete is to be placed on a cold surface of hardened concrete, the hardened concrete must be warmed and its surface sufficiently moistened before the new concrete is deposited. The precautions to be taken in cold weather depend upon the air temperature. Suitable precautions for three different temperature classifications are as follows:

- 40° to 50°F. For air temperatures of 40° to 50°F, the temperature of the placed concrete should be from 60° to 70°F. This can be done by heating the mixing water to a predetermined temperature. For permanent construction, the placed concrete must be cured at a temperature of 50°F for 5 days or 70°F for 3 days. If high-early-strength cement is used, the curing period can be reduced to 2 days at 70°F or 3 days at 50°F.

- 32° to 40°F. For air temperatures from 32° to 40°F, high-early-strength cement should be used, or 2 pounds of calcium chloride per sack of cement should be added to accelerate hardening. Also, it may be necessary to heat the forms to remove ice, snow, or frost. The concrete temperature at the time of mixing should be from 70° to 80°F. This can be obtained by heating the water or heating both the water and aggregate. In no case should the concrete mixing temperature exceed 80°F; higher temperatures will reduce its strength. Remember, the curing conditions described in the previous classification must be provided.

- 0° to 32°F. For air temperatures in this range, high-early-strength cement should be used, however, if this type cement is not available, calcium chloride should be added in the amount of no more than 2 pounds per sack of ordinary cement. Calcium chloride is an accelerator which enables the concrete to develop strength more rapidly. The aggregate and water must be heated to provide a 70° to 80°F concrete temperature at the mixer. It is also advisable to heat the forms. Curing conditions as described in the first classification must be provided.

After the required curing period, the concrete can be allowed to cool to the temperature of the atmosphere, regardless of how cold it is. For massive work, the cooling process should be retarded to a rate not to exceed 20°F in 24 hours. If the cooling rate is not retarded to this value, the concrete will crack. This recommended rate of cooling can be accomplished by controlling the heat supply without removing the inclosure. When the temperature inside the inclosure is the same as the outside temperature, the inclosure can be removed. In some areas, and especially in the Arctic, sudden, sharp frosts are likely to occur. Therefore, means of protecting the concrete must be available at all times. However, concreting should not be done in temperatures below 0°F unless the amount of concrete is exceptionally small or large.

If concrete is frozen before it has taken its initial set, it will not be damaged if thawed out rapidly and properly. It will later develop almost the same strength and durability as it would have if freezing had not occurred. Rapid thawing is performed with the use of heated inclosures.

If concrete is allowed to freeze before it sets up, the water expands and disrupts the bond between the cement and aggregate particles. If the freezing occurs after the concrete has set up and after it has been cured as required, the concrete will not be damaged.

The problem of cold-weather protection is one of preventing loss of heat from concrete placed at a safe initial temperature and of supplying any additional heat needed.

Wooden forms, left in place, furnish protection against temperatures near freezing, but additional protection is necessary for unformed surfaces and exposed corners and edges. To protect these surfaces and edges, insulation board or double sheathing should be used. The most common method of protection is by a heated inclosure such as a framework covered with a tarpaulin. The tarpaulin should provide sufficient space for the circulation of warmed air, and should be tight and windproof. Heat is provided by live or piped steam, or stoves of various types. Steam is preferred because moisture is supplied along with the heat. Portable stoves are convenient for small jobs but have the disadvantage of producing dry heat, giving off fumes and smoke, and producing fire hazards. When portable stoves are used, ventilation must be provided in order to prevent the formation of carbon monoxide.

Less care is required for protection when the concrete is intended for temporary purposes. If the atmospheric temperature is from 20° to 32°F, and no calcium chloride is added, the concrete needs to be protected for a period of 12 hours. This time can be reduced to 6 hours if 2 pounds of calcium chloride per sack of cement is used.

## HOT WEATHER CONCRETING

During hot weather, precautions should be taken to maintain concrete temperature from 85° to 90°F. However, there will be climatic conditions where this limitation cannot be observed. Limitations on the maximum temperature of concrete and the placing of concrete during hot weather are imposed because of the impairment of quality and durability resulting when concrete is mixed, placed, and cured at high temperatures. This impairment affects concrete in three different ways.

(1) The ultimate strength of concrete mixed and cured at high temperatures is never as great as that of concrete mixed and cured at temperatures below 70°F.

(2) The cracking tendencies are increased because of the greater range between the high temperature at the time of hardening and the low temperature to which the concrete will later drop.

(3) Concrete which is mixed, placed, and cured at high temperatures has been found to fail sooner, as a result of repeated cycles of moisture and temperature changes above the freezing point, than concrete which is mixed, placed, and cured at lower temperatures.

The temperature of mixed concrete can be lowered by any of several means. These means include: (1) Using cold mixing water; slush ice can be used in extreme cases to cool the water. (2) Avoiding the use of hot cement. (3) Cooling the coarse aggregate by sprinkling. (4) Insulating mixer drums by cooling them with sprays or wet burlap coverings. (5) Insulating water supply lines and tanks. (6) Shading materials and facilities not otherwise protected from the heat. (7) Working only at night.

The temperature of the mixture can be estimated by using the formula that was earlier given in this section. In hot weather, it is usually necessary to use more cement to obtain the desired consistency. This is true because fresh concrete tends to stiffen rapidly.

Concrete curing is difficult to do in hot weather because the water evaporates rapidly. Proper curing is especially important in hot weather because of the greater danger of crazing and cracking. The efficiency of curing is reduced in hot weather; therefore, moist curing, especially ponding, should be used. Frequent sprinkling and the use of wet burlap and other means of retaining the moisture for longer periods are sometimes necessary.

## SUMMARY

Strengths obtained in concrete are primarily regulated by the curing process. So now, you see why it is of tremendous importance in concrete operations. All preliminary care taken in selection of materials, mixing, forming and placement can be completely destroyed if concrete curing is not properly accomplished.

## QUESTIONS

1. When should curing operations begin?
2. What can be done to protect against evaporation?
3. How long should concrete be cured during hot weather?
4. Why does all concrete need to be cured?
5. What will happen if concrete freezes during the first 24 hours?

# CONCRETE MAINTENANCE AND REPAIR

## OBJECTIVE

This study guide will help you to learn the procedures to inspect and remove a damaged section of concrete, and then mix, place, finish and cure a concrete patch.

## INTRODUCTION

Civil Engineering groups on Air Force installations are continuously maintaining runways and roads constructed of concrete. Constant maintenance is a must in order to prevent minor discrepancies from developing into major rigid pavement repairs. When rigid pavement repair is evident, the work must be performed correctly in order to keep the runways and roads as nearly perfect as possible. The various methods of maintenance and repairs are brought out in this study guide. Again, the objective of maintenance of concrete pavement is to keep it in as near a perfect condition as possible and as structurally sound as traffic, climate, funds, materials, equipment and availability of labor will permit. Essentially, this consists of maintaining a smooth riding surface and keeping the subgrade as dry as possible. A smooth surface protects pavement from destructive effect of traffic impact, reduces wear and tear on vehicles, and is of utmost importance to the safety of aircraft. Prompt and adequate maintenance greatly extends the useful life of a pavement.

## RIGID PAVEMENT MAINTENANCE

### Replacement of Broken Areas

A broken area is a portion of pavement too small to distribute the applied load to the subgrade without settling or rocking; therefore, it must be removed and replaced.

The procedures in the removal and replacement of a broken concrete pavement or slab will be discussed in class and are as follows:

- Inspect broken concrete pavement area.
- Determine portion of pavement which must be removed.
- Obtain necessary tools, equipment, and materials.
- Operate and service air compressor.
- Mark or outline pavement to be removed.
- Saw or groove concrete pavement.

- Break old pavement, using pneumatic pavement breaker, and remove the old concrete.
- Remove unsatisfactory subgrade soil and replace, tamping in layers.
- Clean edges of old slab before placing new concrete.
- Moisten subgrade and edges of old concrete.
- Mix concrete for patch.
- Place, vibrate finish, and cure concrete patch in accordance with AF specifications.

Removal of Concrete

Hand methods are recommended for removing old pavement where patches are few in number, small in area, or widely separated. Twelve- to sixteen-pound stone sledges are used to break the pavement into pieces small enough to be carried by one man. Slabs can be easily broken by raising one edge with a crowbar, inserting a small piece of concrete or a rock under the slab, and striking it with the sledge. When patching large areas, mechanical equipment should be used to speed up operations and reduce cost. The equipment required includes: a portable air compressor, two pneumatic pavement breakers with about 30 feet of air hose for each one, a star bit to be used in a pneumatic drill for very thick concrete, a supply of chisels and moilpoint bits, and small hand tools. The area to be patched is outlined by cutting a groove around it. This groove is usually cut with a pavement breaker, using chisel bits; however, a concrete saw can also be used to outline the pavement. After the old concrete has been removed, the top edge of the cut should be trimmed (straight and vertical) to a depth of 1 inch; otherwise, there will be thin edges in the patch which will spall under traffic. Acute angles (less than 90°) must be avoided in the patch area.

When cutting the slab for utility repairs or installations, the concrete should be cut back about 9 inches beyond the proposed edges of the trench. This will give the patch slab a bearing on undisturbed subgrade. If the trench is very wide, reinforcing steel should be placed at right angles to the trench, 2 inches from the bottom of the slab.

Preparing Pavement for Repairs

Exposed edges of existing concrete pavement, after the defective concrete has been removed, must be prepared to insure a bond between the old pavement and the new concrete mixture. The cleaning of the exposed pavement is accomplished by one of the following methods:

- Sandblasting
- High-pressure water
- Acid (muriatic)
- High-pressure air

## Subgrade

Pavement breakage is usually caused by local conditions of the subgrade, such as frost boils or heave, seepage from a water-bearing layer of soil, subgrade settlement, or other adverse conditions. To avoid repetition of the breakage, these conditions must be corrected before a patch is placed. Poor drainage is corrected by installing subdrains to intercept the water or by lowering the ground-water level as required. Before the patch is placed, unsatisfactory subgrade soil must be removed to a depth of at least 12 inches and replaced with a suitable material firmly packed in layers. If frost heaving is to be prevented in the subgrade, postholes 2 or 3 feet deep, one hole to each 3-yard square of affected area, should be drilled and backfilled with a frost-preventive mix (one part flake calcium chloride to 10 parts sand, fine gravel, or stone screening). Chloride flakes dissolve and percolate through the soil in all directions, lower the freezing point of water in the voids, and protect the subgrade from damaging frost heaves. When trenches are cut through the subgrade to repair or install utilities, they should be carefully cut so that the subgrade along the edges is not disturbed. To prevent future settling, the backfill material should be thoroughly tamped in layers of optimum moisture content.

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Spalling generally occurs adjacent to joints. The definition of a spall is the chipping and breaking away of the pavement at the joint. The causes of spalls are primarily the result of poor construction or inadequate maintenance. Most common causes of spalls are as follows:

- Debris in joints
- Improper finishing of joints
- Improper installation of material
- Joints not at right angles to pavement surface
- Overworking (floating) of the concrete in its plastic state at the joint

Spalled areas will be repaired with portlant cement concrete mixes or with the use of epoxy.

## Scaling

Scaling is the chipping and breaking away of the concrete pavement surface (see figure 55). Scaled bridge decking may require special care when you place the repair mix to insure a proper bond with the existing pavement. Scarifying and scoring the area are important items in the repair.

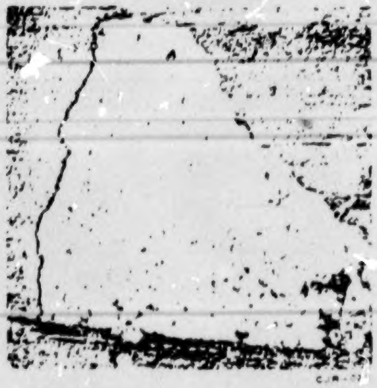

Figure 55. Example of Scaling

## RIGID PAVEMENT REPAIR

The procedures to be followed for repairing concrete were described and outlined under the main heading, "Rigid Pavement Maintenance," of this study guide. The following information also pertains to forming for concrete; placing reinforcement rods; and mixing, placing, finishing, and curing a concrete patch.

### Patch Forming

When it is necessary to use forms for patchwork, the forms may be of steel or lumber. When lumber is used, it must be straight and clean.

### Reinforcing Rod

The amount, kind, and placement of reinforcing steel is determined by the construction engineer. The reinforcing steel may be the rod type of specified diameters, or welded wire mesh meeting federal specifications. The rod or wire mesh is placed in the area and held above the subgrade with chairs. Reinforcing rod is illustrated in figure 56,and wire mesh is illustrated in figure 57.

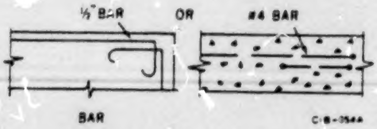

Figure 56. Reinforced Concrete Using Steel Rod

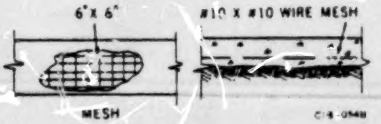

Figure 57. Reinforced Concrete Using Wire Mesh

As previously stated, the reinforcing rod is held in place above the subgrade with high chairs, illustrated in figures 58 and 59.

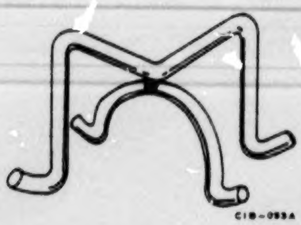

Figure 58. Bar Chair

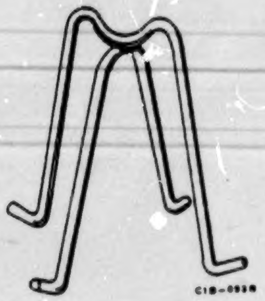

Figure 59. Individual High Chair

## MIXING, PLACING, VIBRATING, FINISHING, AND CURING CONCRETE

The mixture of concrete for the patch will be the standard mix of 1 · 2 · 3 and 6 gallons of water per bag of portland cement.

The subgrade will be moistened to prevent the loss of moisture from the concrete to the subgrade, preventing the concrete from curing at a more rapid rate.

When the concrete is placed, it is vibrated with a pneumatic vibrator, or it may be rodded with shovels to consolidate the mixture. The surface is then struck off with a screed to bring the concrete to the proper elevation.

In finishing the concrete, it will first be floated to bring just enough paste to the surface to apply a nonskid finish. This is accomplished by brooming. Overworking of the concrete in its plastic state will result in sealing and add to more repair problems.

The newly placed and finished concrete is cured. Curing is one of the most important steps in concreting which is frequently overlooking. This is done by one of several methods. The newest and most widely used method is by spraying a curing compound over the surface of the concrete. The curing compound forms a film, preventing the rapid loss of moisture. This aids the concrete in its hydration process and longer cure. Remember, the longer concrete cures, the stronger it gets.

## CONCRETE MIX

In mixing concrete for patches, follow the specifications of the original pavement if they are known and have given good results. Oftentimes, it is desirable to use a mixture which gives a higher early strength than is attained in regular construction work. This will permit the patch to be opened to traffic sooner. Otherwise, patches should be kept closed to traffic until the concrete has a resistance to breakage of at least 550 pounds per square inch. For emergency purposes, the pavement is opened sooner if the possible damage to an occasional patch is justified in order to lessen inconveniece and obstruction to traffic. High-early-strength concrete is ready for traffic in 24 to 74 hours after placing, depending on the temperature, mix used, and other conditions. Three methods are available for preparing high-early-strength concrete.

### Low Water-Cement Ratios

Concrete for patches should be mixed as dry as possible, properly placed, compacted, and finished. A low water-cement ratio (for patches) does not require a mix as rich or with as much cement as is needed for the same water-cement ratio in normal construction procedures. Therefore, high-early-strength concrete is secured without increasing the cement content. Water-cement ratio should not be less than 4 gallons of water to a sack of cement. This will eliminate the difficulties encountered when placing, finishing, or curing concrete. High early strength can be obtained with standard portland cement if an increase of 20 to 25 percent cement is added to the normal concrete mix. However, this increases the shrinkage and should be done only in emergencies.

### High-Early-Strength Portland Cement

High-early-strength portland cements are generally used in mixtures of normal proportions. The water-cement ratio should not be less than 4 gallons of water to a sack of cement.

### Calcium Chloride

Not more than 2 percent of calcium chloride (dry or in solution) by weight of cement is added to the mixture to increase its early strength. When used dry, calcium chloride is placed in the mixer with the aggregate but not in contact with the cement. If in solution, calcium chloride is introduced with the mixing water, replacing an equal volume of the water. Concrete containing calcium chloride hardens quickly and must be placed and finished promptly after mixing.

### Mixing Procedure

At many bases, ready-mixed concrete is available at a reasonable cost. But for small patching jobs, concrete is mixed by hand or in a portable mixer. Concrete is more uniformly and accurately proportioned if all materials are measured by weight. Small, portable scales are used. Water is measured by volume or weight. The amount of water added to each batch must be reduced by the amount of free water which is absorbed by dry aggregates. Hand mixing should continue until an apparently uniform mixture is obtained. Machine mixing should continue for at least 1 minute after all materials are in the mixer.

## PLACING CONCRETE

Before new concrete is placed, the edges of the old slab should be inspected to be sure they are clean and free of dust, dirt, etc. The edges of the old slab should be moist (not wet) when the new concrete is placed. The subgrade should be damp to prevent the absorption of water from fresh concrete. The space to be patched is then filled completely with concrete. Concrete shrinks slightly as it hardens, but the effects of shrinkage can be minimized by tamping after placement.

When concrete is first placed, it is struck off and thoroughly tamped at an elevation slightly higher than the finished surface of the patch. If drier than normal mixes are used, thorough tamping of the entire patch is absolutely essential to insure consolidation, reduction of voids, and elimination of honeycombing in the concrete. The patch should be tamped again as late as possible, but before the concrete hardens beyond the point of finishing. Tamping along the edges must be done to force the fresh concrete tightly against the old slab. This prevents the separation of new and old concrete when the new concrete shrinks during the drying and hardening process. The end of a 2 x 4 timber makes a good edge tamper; however, if a surface vibrator is available, it should be used to better consolidate the patch.

## FINISHING

After final consolidation, the patch should be screened and checked with a straightedge to insure close agreement with the contour of the adjacent pavement. The surface texture of patches should resemble the old pavement. Depending on the method used in finishing the existing pavements, the patch is finished with a canvas, rubber, or wooden belt; a wood float; a burlap drag; or a broom. All transverse and longitudinal joints and outside edges should be edged with an edging tool of 1/4-inch radius. However, the patch is not edged where it joins old pavement.

## CURING

Immediately after finishing operations are completed, curing is started. Continue curing until the patch is opened to traffic. The size of concrete patches and their scattered locations make it inconvenient to cure by frequent or continued application of water. Therefore, other acceptable curing materials which require little or no water (curing membranes, calcium chloride, and impervious paper) should be used. For the dry mixes, the recommended curing materials are applied as soon as finishing operations are completed. If ordinary concrete mixes are used, the curing agents are applied when the patch surface is hard and will not be marred by the application of the agent.

## RIGID PAVEMENT MAINTENANCE USING FAST FIX CEMENT

A fast-setting cement, dubbed "Fast Fix" by the Air Force, originally was developed by the Air Force Aero Propulsion Laboratory, Wright-Patterson AFB, Ohio, to provide a technique for rapidly restoring bomb-damaged runways. Fast Fix in 30 minutes developed strengths comparable to normal 28-day concrete. The Fast Fix-Mass Application concept developed for this effort was successfully demonstrated by the Air Force at Eglin AFB, Florida, during August 1967 when the upper 1-foot section of a 70-foot diameter simulated bomb crater was repaired in approximately 1 hour. In this repair, Fast Fix in the neat slurry form (dry cement and mixing water) was applied at a rate of 1000 g. p. m. and allowed to percolate down through aggregate placed in the upper portion of the crater to produce an in-place concrete.

Fast Fix concrete can be mixed in conventional revolving drum-type concrete mixers. Fast Fix concrete, like portland cement concrete, incorporates sand and crushed rock or gravel, and requires only the skills needed to mix and handle conventional concrete. Also, Fast Fix is applicable as a sand slurry cement in which sand is incorporated with the dry cement and mixing water.

### Fast Fix Characteristics

Fast Fix slurry cement in 30 minutes develops compressive and flexural strengths of 3500 p. s. i. and 600 p. s. i., respectively. Also, it is nonshrinkable (it expands slightly), nontoxic, nonflammable, and self-leveling. The consistency of the material is similar to that of buttermilk which allows for the self-leveling characteristic. The set time of Fast Fix when mixed with 35 percent water is approximately 12 minutes. The set time is the point at which this material becomes solidified. Fast Fix concrete is practically self-leveling in that it has a slump of approximately 11 to 11-1/2 inches. These characteristics of Fast Fix are desirable for runway repair in that (1) it is easy to handle, (2) will flow into the irregularities of the broken runway pavement, and (3) can be contoured to the slope of the existing pavement. The self-leveling characteristic of Fast Fix neat slurry cement can be controlled by diking the low sides of the crater and filling to the crown or high point of the runway surface. The excess Fast Fix can be removed and contoured to the existing pavement surface with a roadgrader 5 to 10 minutes after it has set.

## SUMMARY

Again, the objective of rigid pavement repair is to keep the pavements in as near the original condition as possible.

QUESTIONS

1. What is the first step in rigid pavement repair and maintenance?
2. What causes a concrete pavement to scale?
3. Scaling appears as what?
4. Shallow scaling is how deep?
5. When using a cement mortar patch to repair a scaled area, what is the recommended mix?
6. When using lumber for forming concrete patches, the lumber should be ______________________ and ______________________.
7. What are two different types of reinforcement steel?
8. When placing fresh concrete on the subgrade, why is the subgrade moistered?
9. How is a concrete patch cured?
10. What is the result of concrete being overworked while in a plastic state?

REFERENCES

CDC 55233, Masonry Specialist.

# FORM REMOVAL

## OBJECTIVE

This study guide will help you gain the necessary background information and procedures to remove, clean, and store concrete forms; and finish the concrete surface.

## INTRODUCTION

To finish a concrete job successfully, the forms must be removed and the concrete rubbed to a desirable finish.

When you have completed this unit of instruction, you will be able to remove wall forms; clean surface with a carborundum stone; fill voids; and clean and store forms.

## REMOVING WALL FORMS

In removing wall forms, care must be taken so the concrete will not be damaged. First, remove all the stakes and take off the wales; then you can remove the wall frames. Use wooden wedges to pry the forms away from the walls so the wall will not be damaged. As the forms are removed, remove all protruding nails to prevent possible personal injury. Stack the forms away from the wall so they will not be in the way when the wall is cleaned.

## SURFACE CLEANING WITH A CARBORUNDUM STONE

A carborundum stone is used to remove stains and smooth concrete walls. The first rubbing should be done with a coarse carborundum stone as soon as the concrete has hardened enough so the aggregate will not be pulled out. The concrete should then be cured and then given a final rubbing with a fine stone. Whenever you use a carborundum stone, keep the concrete damp while it is being rubbed.

## FILLING VOIDS

After the surface has been cleaned, you can proceed to fill the voids. Voids form when a concrete mix is too dry or when the concrete has not been vibrated. The voids may be filled by using either grout or a slurry paste.

### Grout

Grout is prepared by mixing equal parts of sand and cement with enough water to form a thick paste. The grout is applied with a pointing trowel, taking care to completely fill the voids.

### Slurry Paste

Slurry paste is basically the same mixture as grout, except that enough water is added to make a thin paste. The paste is then applied to the wall surface with a stiff brush, taking care to fill all voids. The wall is then rubbed down with a wood or sponge float to insure that all holes are filled. After using slurry paste, the wall should be dampened lightly to keep the concrete from absorbing the water from the slurry paste. When the surface has hardened, rub the surface with burlap to remove the excess paste.

## CLEANING, OILING, AND STORING FORMS

Clean, oil, and store the forms after the wall has been cleaned. Brush off excess concrete with a stiff wire brush; then apply a light coat of oil to act as a bond breaker. The oil can be either brushed or sprayed onto the forms. Stack steel forms in their order of erection; the form panel to be used first placed on top of the stack.

## MATERIALS AND METHODS USED IN CURING CONCRETE

As soon as the concrete has hardened enough so that the surface will not be marred, the burlap, canvas, or building paper can be replaced with coverings of earth, sand, or straw that has been kept moist for at least 3 days by occasional sprinkling.

Another method of moist curing is ponding. This is done by keeping about 1 inch of water on the concrete surface. The water can be confined by earth dikes around the edges of the slab. Early drying must be prevented or the concrete will not reach its full potential strength.

Concrete surfaces can also be cured with commercial curing compounds (containing wax or resin) if they seal the surface without penetrating. With the use of curing compounds, the concrete will cure for an indefinite period of time while the slab, sidewalk, etc., are in use.

When using curing compounds, follow the manufacturer's instructions for application. Precautions must be taken when placing, finishing, and curing concrete in excessively hot or cold temperatures.

Table 6. Curing Methods

| Method | Advantage | Disadvantage |
|---|---|---|
| Sprinkling with water or covering with wet burlap. | Excellent results if constantly kept wet. | Likelihood of drying between sprinklings. Difficult on vertical walls. |
| Straw | Insulator in winter. | Can dry out, blow away, or burn. |
| Curing Compounds | Easy to apply. Inexpensive. | Sprayer needed; inadequate coverage allows drying out; film can be broken or tracked off before curing is completed; unless pigmented, can allow concrete to get too hot. |
| Moist earth | Cheap, but messy | Stains concrete, can dry out, removal problem. |
| Waterproof paper | Excellent protection, prevents drying. | Heavy cost can be excessive. Must be kept in rolls, storage and handling problem. |
| Plastic film | Absolutely watertight, excellent protection. Light and easy to handle. | Should be pigmented for heat protection. Requires reasonable care and tears must be patched; must be weighed down to prevent blowing away. |

## SUMMARY

When removing wall forms, take care not to damage the wall surface. Use wooden wedges to pry the form away from the wall. Carborundum stones are used to clean stains and excess concrete from wall surfaces. Voids may be filled using either grout or a slurry paste. Steel forms must be cleaned with a stiff fiber brush; oiled and then stacked in their order of usage.

To maintain the strength of concrete, it must be kept moist during the first few days after the concrete is poured. Without curing, the maximum strength of concrete is less than when curing is used.

QUESTIONS

1. What is used to fill voids?
2. Why should care be taken in removing forms?
3. Why would you use a carborundum stone?
4. How is slurry paste applied to the wall surface?
5. When and why is the wall surfaces rubbed down with burlap?

REFERENCES

CDC 55233, Masonry Specialist

WORKBOOKS

3ABR55233-II-1-P1 thru -II-9-P1

3-19

Technical Training

# Masonry Specialist

# RIGID CONCRETE STRUCTURES

November 1975

USAF SCHOOL OF APPLIED AEROSPACE SCIENCES
Department of Civil Engineering Training
Sheppard Air Force Base, Texas

Designed For ATC Course Use

DO NOT USE ON THE JOB

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This supersedes WB 3ABR55233-II-1-P1 thru II-9-P1, 5 July 1973. (Copies of the superseded publication may be used until supply is exhausted)

Department of Civil Engineering Tng
Sheppard AFB, Texas

WB 3ABR55233-II-1-P1
November 1975

## PREPARING CONCRETE MIXTURES

### OBJECTIVE

Upon completion of this workbook you will be able to prepare a concrete design mix and perform a slump test.

### EQUIPMENT

| | Basis of Issue |
|---|---|
| SG 3ABR55233-II-1 | 1/student |
| WB 3ABR55233-II-1-P1 | 1/student |
| Pencil | 1/student |
| Paper | 1/student |
| Slump cone and rod | 4/student |
| Wheelbarrow | 4/student |
| Shovel | 4/student |
| Hoe | 4/student |

### PROCEDURE

#### Mission 1

Answer the following questions pertaining to concrete material and their use in concrete construction. SG 3ABR55233-II-1 and class notes may be used as references.

1. What safety precautions should be observed when lifting cement bags? ________

______________________________________________________________

2. How high should portland cement be stacked? ______________________

3. Aggregate passing through a number ____________ sieve is considered fine aggregate.

4. What test is used to determine the cleanliness of fine aggregates? ____________

______________________________________________________________

5. Air entrained cement is designated by what mark on portland cement bags?

______________________________________________________________

6. In a number eight sieve there are __________ openings per square inch.

7. A hardened mixture of cement, sand, gravel, and water would be the definition of ______________________________.

8. Fill in the blanks below with the type of cement that corresponds to the descriptions given.

| | TYPES | | DESCRIPTIONS |
|---|---|---|---|
| a. | ____________ | (1) | Produces less heat during hydration. |
| b. | ____________ | (2) | Sulfate resistant. |
| c. | ____________ | (3) | High early strength. |
| d. | ____________ | (4) | Most commonly used. |
| e. | ____________ | (5) | Used for massive concrete pours. |

9. Name three types of aggregates.

a. ________________________________________

b. ________________________________________

c. ________________________________________

10. A concrete additive that enables concrete to resist freezing and to protect pavements from adverse effects of salts during snow removal is ______________________________.

11. What is the largest size of coarse aggregate normally used? ________________________________________

12. How would you store cement outside? __________

________________________________________________________

________________________________________________________

________________________________________________________

________________________________________________________

13. Why is it necessary to determine the moisture content of aggregate before preparing a concrete mix?

14. When referring to aggregate, what is meant by the term "saturated surface dry"?

15. What type of apparatus is used for a slump test?

16. What type of sand is normally used?

17. What type of cement would you use for repairs on a runway that was to be put into use the following day?

18. Name the additive that causes each cubic foot of concrete to contain billions of tiny air bubbles.

19. What are the advantages of using air entrained cement?

20. What is type IV concrete used for?

## Mission 2

Prepare a concrete design, mix and perform the slump test by following the step-by-step procedures listed below.

1. Instructor will provide the student with a slump cone and a pointed rod.

2. Students will mix three batches of concrete, using the following mixes:

   a. 16 lbs of cement

   b. 32 lbs of sand

   c. 48 lbs of aggregate

   d. Water by weight

      (1) Batch number one - 14.56 lbs.

      (2) Batch number two - 15.24 lbs.

      (3) Batch number three - 15.90 lbs.

3. Fill the slump cone one-third full of concrete.

4. Rod the concrete 25 times with pointed rod.

5. Fill the slump cone two-thirds full of concrete.

6. Rod the concrete 25 times with pointed rod.

7. Fill the slump cone full of concrete.

8. Rod the concrete 25 times with pointed rod and smooth top of cone.

9. Remove slump cone from the concrete.

10. Place slump cone near concrete; place the pointed rod across top of cone and concrete. Using a ruler, measure the distance between the rod and top of concrete; this will be the slump test.

11. Record results of the slump test in the blanks provided below.

   a. Batch number 1, damp sand. ____________________

   b. Batch number 2, wet sand. ____________________

   c. Batch number 3, very wet sand. ____________________

## PREPARING SITE FOR CONCRETE

### OBJECTIVE

Upon completion of this workbook you will be able to prepare a site for a concrete slab and to compute THE AMOUNT OF CONCRETE NEEDED for a given project.

### EQUIPMENT

| | Basis of Issue |
|---|---|
| SG 3ABR55233-II-2 | 1/student |
| WB 3ABR55233-II-2-P1 | 1/student |
| Pencil | 1/student |
| Paper | 1/student |
| Pneumatic Tamper | 1/12 student |
| Vibrator Tamper | 1/12 student |
| Shovels (round point) | 1/3 student |
| Shovels (square) | 1/3 student |
| Wheelbarrows | 1/3 student |
| Sledge hammer | 1/6 student |
| 50' steel tape | 1/12 student |
| Steel forms | 1/12 student |
| Builder's level | 1/12 student |
| Hammer | 1/student |
| Nails | 1/student |
| Saw | 1/6 student |
| 2 X 4 lumber | 1/12 student |
| Rake | 1/3 student |
| Gravel | 1/12 student |
| Layout line | 1/12 student |
| Mason handtools | 1/student |

### PROCEDURE

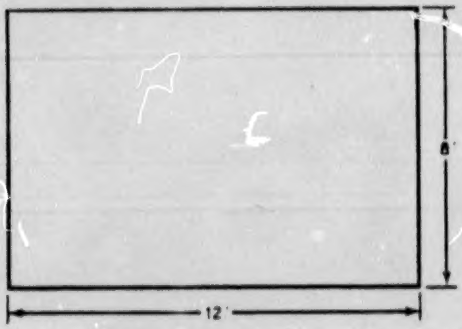
### Mission 1

### COMPUTE THE AREA

1. Compute the area of the following rectangles.

2. Give your answer in both square feet and square yards.

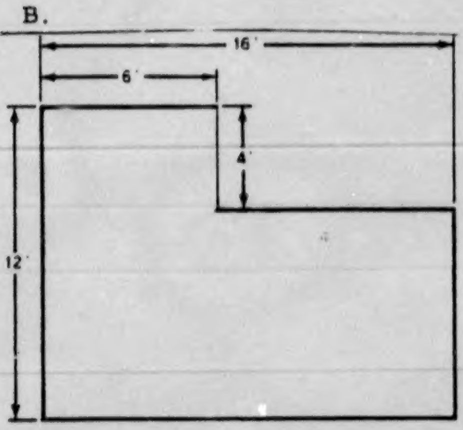
A.



Area ____________ Sq ft

____________ Sq yds

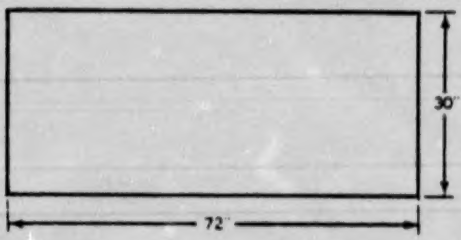
B.



Area ____________ Sq ft

____________ Sq yds

C.



Area ____________ Sq ft

____________ Sq yds

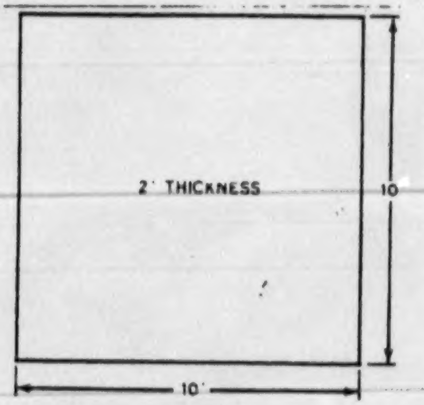
## MISSION 2

## COMPUTE VOLUME

1. Compute the volume of the following areas.

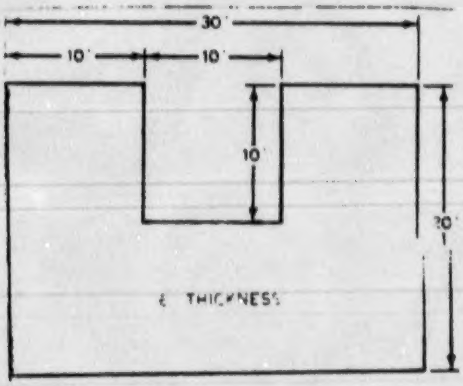
2. Give your answer in cubic yards.

a.


2' THICKNESS
10'
10'

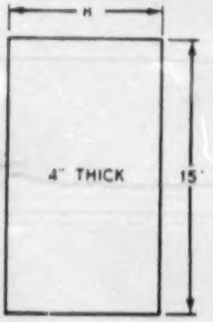
Volume ______ Cu. yds.

b.


30'
10'
10'
10'
20'
8' THICKNESS

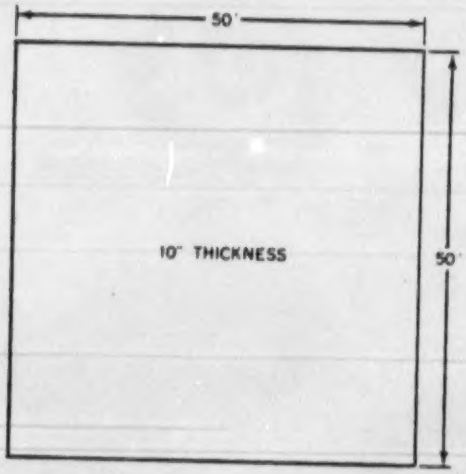
Volume ______ Cu. yds.

c.



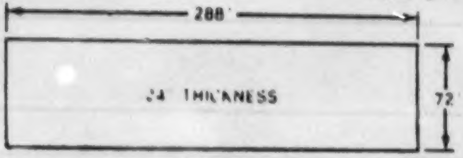
Volume ______ Cu. yds.

d.


50'
10" THICKNESS
50'

Volume ______ Cu. yds.

e.


288'
24" THICKNESS
72'

Volume ______ Cu. yds

Mission 3

## PREPARING SUBGRADE FOR CONCRETE SLAB

1. Measure and stake off area for construction.
2. Remove vegetation.
3. Remove topsoil.
4. Check subsoil for soft and hard spots.
5. Compact the subsoil using the vibrator compactor.
6. Set steel forms and check for proper alignment.
7. Use a builder's level and check the forms to determine that they are level.
8. Doublecheck all of your work.
9. Have the instructor check your work.

Instructor

## BUILDING FORMS FOR CONCRETE

### OBJECTIVE

Upon completion of this workbook you will be able to build forms for concrete walls.

### EQUIPMENT

| | Basis of Issue |
|---|---|
| SG 3ABR55233-II-2 | 1/student |
| WB 3ABR55233-II-2-P2 | 1/student |
| Pencil | 1/student |
| Paper | 1/student |
| Shovels | 6/student |
| Sledge hammer | 6/student |
| 50' steel tape | 12/student |
| Layout line | 12/student |
| Plywood wall forms | 12/student |
| Mason handtools | 1/student |

### PROCEDURE

#### Mission 1

NOTE: In this area you will make a concrete wall 16 feet long, 2 feet high, and 8 inches wide. (See figure 1)

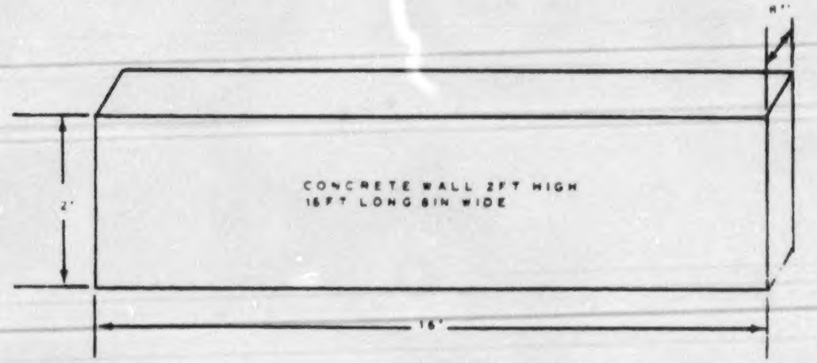


Figure 1

1. Construct a wood wall form, as shown in figure 2. Follow the instructions given you by the instructor.

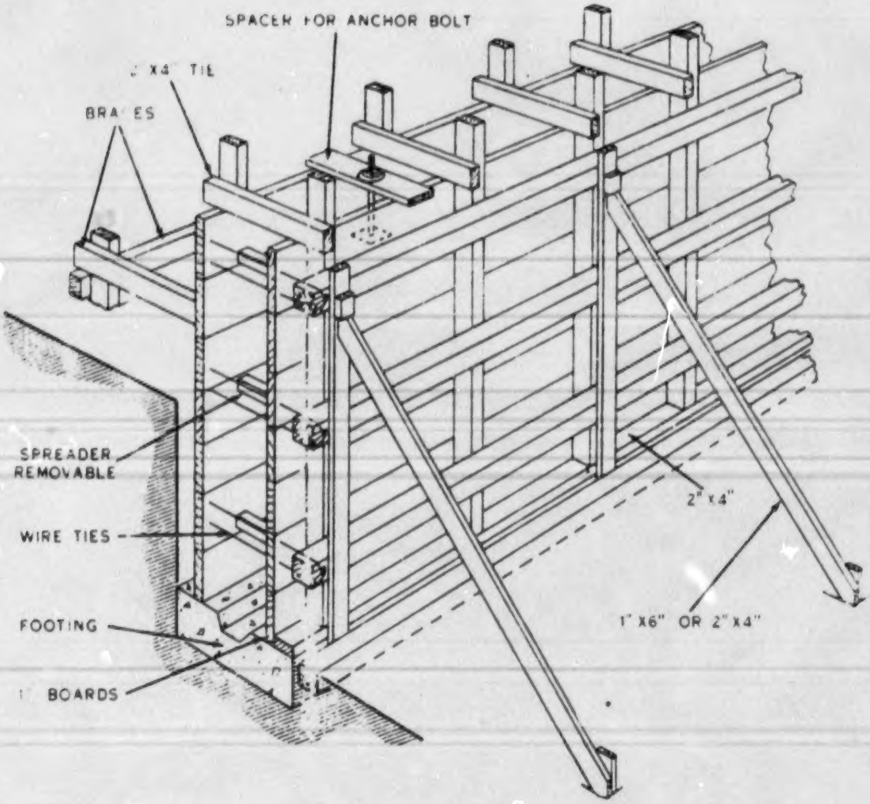

SPACER FOR ANCHOR BOLT
2" X4" TIE
BRACES
SPREADER REMOVABLE
WIRE TIES
FOOTING
1" BOARDS
2" X4"
1" X6" OR 2" X4"

Figure 2

2. Use the following checklist to determine if a concrete form is properly prepared.

1. Is the form in the correct place?
2. Is the form of the correct size and shape?
3. Are the studs placed properly?
4. Are the wales placed properly?
5. Are there enough braces and stakes?
6. Is the form strong enough?
7. Are all the joints tight?
8. Is the wall sheathing spaced properly?
9. Are the forms level?
10. If there are anchor bolts, are they placed properly?
11. Is the interior of the form walls oiled?

# INSTALLING REINFORCEMENT MATERIAL

## OBJECTIVE

Upon completion of the workbook you will be able to select, measure, cut, bend, and install reinforcement material.

| EQUIPMENT | BASIS OF ISSUE |
|---|---|
| SG 3ABR55233-II-3 | 1/student |
| WB 3ABR55233-II-3-P1 | 1/student |
| Bending table | 1/12 student |
| Bolt cutter | 1/3 student |
| Pliers | 1/3 student |
| Six-foot rule | 1/3 student |
| Steel mesh | |
| Steel bars | |
| Soft iron wire | |

## PROCEDURE

### Mission 1

NOTE: Before accomplishing the following projects, obtain necessary specifications from your instructors.

Installing Wire Mesh in a Slab Form

1. Estimate the amount of steel wire mesh you will need.

2. Unroll wire mesh and cut to length with bolt cutters while observing safety precautions.

3. Place wire mesh in forms.

4. Check for correct overlap (minimum 6 inches).

5. Install spacer blocks as directed.

### Mission 2

Installing Steel Bars in a Wall Form

1. Install wooden spacer blocks at the top and bottom of form.

2. Install vertical bars.
3. Install horizontal bars, tying them to the vertical bars as the work progresses.
4. Check for correct bar spacing.

### Mission 3

Forming Vertical Columns

1. Cut steel bars to correct length.
2. Bend bars on the bar bending table.
3. Tie the rectangular bar assembly to the vertical bars.
4. Check for correct bar spacing.

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## PLACING CONCRETE FOR A SLAB

### OBJECTIVES

When you have completed this workbook you will be able to mix, place, and finish concrete in slab forms.

### EQUIPMENT

| | Basis of Issue |
|---|---|
| SG 3ABR55233-II-4 | 1/student |
| WB 3ABR55233-II-4-P1 | 1/student |
| Concrete mixer (6 cu ft capacity) | 1/student |
| Water Hose (if required) | |
| Screed board | 1/student |
| Wood floats | 1/3 student |
| Steel trowels | 1/3 student |
| Edging board | 1/3 student |
| Burlap or curing compound (as prescribed) | |
| Portland cement (amount required) | |
| Fine aggregate (amount required) | |
| Coarse aggregate (amount required) | |
| Water | |

### INSTRUCTIONS

Working as a team, each member of the class will participate in each phase (mixing, placing, finishing) of the project to construct a concrete slab structure. The mixture ratio for the structure will be prescribed by the instructor.

NOTE: Safety precautions will be observed throughout this performance.

### Mission 1

Using the Concrete Mixer:

1. Following the preoperational safety inspection guide on concrete mixers, perform preoperational and operational safety check on mixer. Place a checkmark in the appropriate space as each item is inspected.

a. Preoperational inspection

(1) __________ Check for safety chain connection to hopper.

(2) __________ Remove towing tong.

(3) __________ Check wheels on mixer for secure emplacement.

(4) __________ Check engine oil supply for full condition, add oil if needed.

(5) __________ Check fuel supply and service if needed.
FOLLOW ESTABLISHED SAFE SERVICING PROCEDURES.

(6) __________ Check lift cable for proper wind on pulley.

b. Operational safety guide.

(1) __________ Clear everyone from hopper travel.

(2) __________ Start mixer engine.

(3) __________ Engage clutch.

(4) __________ Insure that everyone is clear of the hopper travel.

(5) __________ Disconnect safety chain.

(6) __________ Release hopper to full down position slowly.

(7) __________ Observe cable unwinding (allow to unwind slowly).

(8) __________ Raise hopper until hopper knocks emptying concrete materials into mixing drum.

## Mission 2

Following these instructions, mix concrete.

1. Place material into hopper.

   a. Cement

   b. Fine aggregate

   c. Coarse aggregate

2. Raise hopper.

3. Allow materials to mix dry.

4. Add 6 gallons of water.

5. Mix for 1 1/2 minutes.

## Mission 3

### Transport and Place Concrete

1. Extract concrete from mixer into wheelbarrows.

2. Transport concrete to formed area.

3. Consolidate concrete into forms with shovels as being placed.

4. Using screed board, bring concrete to proper level (elevation).

5. Float concrete, being careful not to overwork, bringing too much paste to surface.

## Mission 4

### Finish and Curing Concrete

1. Perform a preoperational check on the power trowel as follows and place a checkmark in the space provided as you perform each individual inspection.

   a. ________ Check engine oil supply for full condition; add oil if necessary.

   b. ________ Check fuel supply and service if needed.
   FOLLOW ESTABLISHED SAFE SERVICING PROCEDURES.

   c. ________ Check for security of all nuts and bolts.

   d. ________ Check each individual trowel blade for alignment.

2. Allow concrete to hydrate and set until ready to trowel.

3. Use edging tool and edge pavement.

4. Using burlap or curing compound, cure pavement.

## Mission 5

Postoperational and Cleanup

1. Clean mixer and all equipment.
2. Perform postoperational safety check on mixer.
    - a. ________ Raise hopper.
    - b. ________ Connect safety chain.
    - c. ________ Connect towing tongue (if mixer is towed).
    - d. ________ Turn switch OFF.

3. Postoperational safety of the power trowel.
    - a. ________ Clean power trowel.
    - b. ________ Coat trowel blades with oil.
4. Return mixer, trowel, and all tools and equipment to designated storage areas.

# PLACING CONCRETE FOR A WALL

## OBJECTIVE

When you have completed this workbook, you will be able to mix, place, and finish concrete for a wall structure.

## EQUIPMENT

| | Basis of Issue |
|---|---|
| SG 3ABR55233-II-4 | 1/student |
| WB 3ABR55233-II-4-P2 | 1/student |
| Concrete mixer | 1/12 student |
| Water hose | 1/12 student |
| Screed board | 1/3 student |
| Steel trowels | 1/3 student |
| Steel edger | 1/3 student |
| Wheelbarrow | 1/3 student |
| Portland cement | |
| Fine aggregate | |
| Coarse aggregate | |
| Water | |

## INSTRUCTIONS

The members of the class will participate as a team to mix, place, and finish concrete wall structures. The mixtures used for the structure will be prescribed by the instructor.

NOTE: Safety precautions will be observed throughout this performance.

1. Following the preoperational safety inspection guide on the concrete mixer, perform preoperational and operational safety check on mixer.

   a. Preoperational inspection

      (1) __________ Check for safety chain connection to hopper.

      (2) __________ Remove towing tong.

      (3) __________ Check wheels on mixer for secure emplacement.

      (4) __________ Check engine oil supply for full condition, add oil if needed

      (5) __________ Check fuel supply and service if needed.
      FOLLOW ESTABLISHED SAFE SERVICING PROCEDURES

      (6) __________ Check lift cable for proper wind in pulley.

b. Operational Safety Guide

(1) ________ Clear everyone from hopper travel.

(2) ________ Start mixer engine.

(3) ________ Engage clutch.

(4) ________ Insure everyone is clear of hopper travel.

(5) ________ Disconnect safety chain.

(6) ________ Release hopper to full down position slowly.

(7) ________ Observe cable unwinding (allow to unwind slowly).

(8) ________ Raise hopper until hopper knocks emptying concrete materials into mixing drum.

2. Mixing Concrete

a. Place material into hopper.

(1) Cement

(2) Fine aggregate

(3) Coarse aggregate

b. Raise hopper.

c. Allow materials to mix dry.

d. Add 6 gallons of water.

e. Mix for 1 1/2 minutes.

3. Transporting and Placing Concrete

a. Extract concrete from mixer into wheelbarrows.

b. Transport concrete to formed area.

c. Consolidate concrete into forms with shovels as being placed.

d. Using screed board, bring concrete to proper level (elevation).

4. Finishing concrete

a. Allow concrete to hydrate and set until ready to trowel.

b. Use edging tool and edge pavement.

5. Clean Mixer and All Equipment

6. Postoperational Safety Check

   a. _______ Raise hopper.

   b. _______ Connect safety chain.

   c. _______ Connect towing tongue (if mixer is towed).

   d. _______ Turn switch OFF.

# CURING CONCRETE SLABS AND WALL STRUCTURES

## OBJECTIVE

When you have completed the mission in this workbook, you will be able to:

Apply the material to effect a satisfactory cure of concrete and structures.

## EQUIPMENT

| | Basis of Issue |
|---|---|
| SG 3ABR55233-II-5 | 1/student |
| WB 3ABR55233-II-5-P1 | 1/student |
| Pencil | 1/student |
| Spray Applicator | 1/12 students |
| Polyethylene Sheets | 1/12 students |

### Mission 1

1. List the material that may be used to satisfactorily cure concrete.

a. ______

b. ______

c. ______

d. ______

e. ______

f. ______

g. ______

h. ______

2. List two important characteristics that concrete acquires as a result of proper curing.

a. ______

______

______

b. ______

______

______

3. Name the methods used in final curing of concrete.

a. ______________________________

b. ______________________________

c. ______________________________

4. Name the type of cement, or additive, that should be used when pouring concrete when air temperature range is 32° to 40°F.

a. ______________________________

b. ______________________________

5. List ways temperature of mixing concrete could be lowered during hot weather concreting.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

## Mission 2

Caution: Insure all air pressure is completely released from spray applicator tank prior to attempting removal of cap from tank. This may be done by slowly unscrewing the pump cap until air is heard escaping through the air relief holes in the side of the pump cap. After the air has been completely removed from the tank, it is then safe to completely remove the pump cap.

1. Obtain spray applicator.

2. Check tank for air pressure, slowly remove pump cap. (See Caution.)

3. Check spray applicator for any visible damage.

4. Replace pump cap--screw on by hand until tight, operate hand pump and check for air pressure buildup. (Tank empty.)

5. Point spray nozzle away from body, press hand release on hose assembly, and release air through nozzle for few seconds.

6. Release remainder of air pressure from tank by again slowly removing pump cap (see caution).

7. Fill applicator tank three-fourths full. Balance of space left for air. Replace pump cap. Tighten securely.

8. Operate pump until about 50 to 60 lbs pressure is in tank. (Do not let air pressure get too low, 50 to 60 lbs produces a fine mist during application procedures.)

9. Apply compound solution to specified area in thin uniform, continuous film. If second coat of compound is needed, spray direction should be at right angles of first application direction.

10. When completed, release remaining air pressure in tank (see Caution). Replace compound with clear water and rinse thoroughly and return spray applicator to proper storage area.

# REPAIRING DAMAGED CONCRETE

## OBJECTIVE

Upon completion of this workbook, you will be able to inspect and remove a damaged section of concrete and then mix, place, finish, and cure a concrete patch.

## EQUIPMENT

| | Basis of Issue |
|---|---|
| SG 3ABR55233-II-6 | 1/ student |
| WB 3ABR55233-II-6-P1 | 1/ student |
| Pencil | 1/ student |
| Paper | 1/ student |
| Air Compressor | 1/12 student |
| Jackhammer | 1/12 student |
| Concrete Mixer | 1/12 student |
| Wheelbarrow | 1/6 students |
| Pneumatic Tamper | 1/12 student |
| Vibrator Tamper | 1/12 student |
| Shovels | 1/6 student |
| Sledgehammer | 1/6 student |
| 2 X 4 Lumber | 1/12 student |
| Nails | 1/6 student |
| Skill Saw | 1/12 student |
| Mason Handtools | 1/ student |

### Mission 1

Answer the following questions with the aid of your notes and study guide 3ABR55233-II-6, Concrete Maintenance and Repair.

1. What are the three methods of repairing spalls? ______________________________

______________________________________________________________

2. What is the depth for cutting a spall with a concrete saw? ____________________

______________________________________________________________

3. When repairing spalls, the concrete is cleaned by two methods What are they?

______________________ and ______________________________

4. What causes concrete pavements to have popouts? ____________________________

______________________________________________________________

5. Popouts are repaired in what method? ____________________

________________________________________

________________________________________.

6. What is the first step in the removal and placement of a broken concrete pavement?

________________________________________

________________________________________.

7. Briefly explain how broken concrete pavement areas are removed.

________________________________________

________________________________________

________________________________________.

8. List four methods of cleaning the exposed edge of an old concrete pavement, before placing a new concrete mixture against it.

a. ____________________________________

b. ____________________________________

c. ____________________________________

d. ____________________________________

9. What are three causes of concrete pavements breaking?

a. ____________________________________

b. ____________________________________

c. ____________________________________

10. How are spalls repaired with cement? ____________________

________________________________________

________________________________________.

11. What is the last step in the removal and replacement of broken concrete pavements?

________________________________________

________________________________________.

12. What are the five causes of spalls?

    a. ______________________________

    b. ______________________________

    c. ______________________________

    d. ______________________________

    e. ______________________________

13. How are spalls repaired with epoxy? ______________________________

    ______________________________

    ______________________________

14. What is purpose of contraction joints? ______________________________

    ______________________________

PROCEDURE

### Mission 2

You will inspect and remove a damaged section of concrete designated by the instructor and prepare the area for repair, following the outlined procedures.

1. Inspect defective concrete area.

2. Determine portion of concrete which must be removed.

3. Air Compressor: Operational Procedures

   a. Safety Precautions

      (1) Secure loose hose before starting.

      (2) Open service valves before starting.

      (3) Stay clear of air blast

      (4) Keep close surveillance of air pressure gage.

      (5) Remove all jewelry.

      (6) Goggles will be worn when using attachments with air compressor.

b. Preoperational Check

(1) Set unit on level ground.

(2) Check level of engine crankcase oil and compressor oil.

(3) Check level of fuel and radiator coolant.

(4) Pull out idle control cable.

(5) Press starter button, release when engine starts.

NOTE: If engine fails to start within 30 seconds, stop and wait a short period of time.

(6) In extremely cold weather, use ether capsule to assist starting.

(7) Close drain valve on pressure tank.

c. Operational Check

(1) Operate engine at idle until engine temperature reaches operating range of 120° F. Push in idle control cable.

(2) Maintain minimum air pressure of 110 p.s.i. during operation.

d. Postoperational Check

(1) Close service valves and run 5 minutes before shutdown.

(2) Stop engine by pulling stop cable.

(3) Open drain valve on pressure tank.

(4) Clean and service compressor before storage.

4. Jackhammer: Operational Procedures

a. Wear safety goggles and gloves.

b. Check to ensure oil is on connection end of bit and in the piston chamber.

c. Connect air hose and secure with safety wire.

d. Proceed to operate safely.

5. Concrete Saw: Operational Procedures

a. Safety Precautions

(1) Keep hands and feet away from saw blade while in operation.

    (2) Wear goggles while operating saw.
    (3) Remove all jewelry.
    (4) Sweep area before sawing.

b. Preoperational Check

    (1) Check fuel.
    (2) Check oil level.
    (3) Check tightness of blade.
    (4) Connect supply source of water.
    (5) Lower blade to 1/2 inch of cutting surface.

c. Operational Check

    (1) Start engine
    (2) Turn water on blade
    (3) Lower blade to desired depth
    (4) Release brake
    (5) Follow line to be cut
    (6) Set brake
    (7) Raise blade
    (8) Cut off water supply

d. Postoperational Check

    (1) Shut off engine
    (2) Disconnect water supply
    (3) Visual inspection of machine
    (4) Clean and service as required

6. Vibrator Tamper: Operational Procedures

a. Safety Precautions

    (1) Remove all jewelry

- (2) Do not refuel while running
- (3) Keep feet free of tamper

b. Preoperational Check

- (1) Make sure machine is level
- (2) Check fuel and oil
- (3) Check for loose nuts and bolts
- (4) Check tamper plate adjustment

c. Operational Check

- (1) Turn on gas
- (2) Start Engine
- (3) Let idle till warm
- (4) Open throttle wide

d. Postoperational Check

- (1) Idle engine down
- (2) Switch engine off
- (3) Visual inspection of machine
- (4) Cut off gas
- (5) Clean and service as required

7. Methods of Removing Damaged Area

   a. Cut damaged area perimeter out with concrete saw.

   b. Remove damaged area with air compressor and jackhammer.

   c. Remove debris with shovels and wheelbarrow.

   d. Compact subgrade with vibrating tamper.

## Mission 3

You will mix, place, finish, and cure concrete in the damaged area previously removed.

1. Methods of Preparing Subgrade and Edge of Old Slab.

   a. Brush edge of existing slab free of all debris and dust.

   b. Wet subgrade with water.

   c. Brush edges of existing slab with a bonding agent.

2. Reinforcement Steel Placement

   a. Secure rebar to existing pad mechanically and use chairs or supports to keep rebar from touching ground.

   b. Expanded wire mesh can be used for thin slab construction reinforcement.

3. Concrete Mixture

   Concrete Mixer Operating Procedures:

   a. Safety Precautions

      (1) Remove all jewelry.

      (2) Check safety chain holding in up position.

      (3) Keep all personnel clear of machine while in operation.

      (4) Stay upwind from cement.

   b. Preoperational Procedures

      (1) Check safety chain on hopper.

      (2) Remove towing bar.

      (3) Chock wheels.

      (4) Check engine oil.

      (5) Check fuel.

      (6) Check lift cables,

   c. Operating Procedures

      (1) Clear all personnel away from hopper,

(2) Ensure clutch is disengaged.

(3) Start engine.

(4) Engage clutch to rotate drum.

(5) Lower hopper to full down position slowly.

(6) Observe cable unwinding off spool.

(7) Fill hopper with proper materials.

(8) Raise hopper until it hits automatic shaker emptying materials into the rotating drum.

(9) Mix no less than one minute.

(10) Dispense concrete from drum.

d. Postoperating Procedures

(1) Raise hopper.

(2) Connect hopper safety chain.

(3) Connect towing bar.

(4) Turn off switch.

(5) Clean and service mixer as required.

Mixture To Be Used

1 - Part Portland cement

2 - Parts sand

3 - Parts gravel

6 Gal. W/C ratio

4. Repair Procedures

a. Place concrete in area to be patched.

b. Screed off concrete to match existing pad.

c. Finish concrete with wooden floats and steel trowel to match existing pad.

d. Protect patched area from elements.

e. Cure patched area

## Mission 4

When you have completed this mission, you will be able to seal a joint with caulking compound and patch a crack with mortar.

### Sealing Joints

1. Pull pressure plate on caulking gun to the rear of the gun.
2. Place caulking tube into the gun barrel.
3. Move pressure plate until it is inside the tube.
4. Cut the tube nozzle to the desired size and angle.
5. Start at the top of the joint and fill the joint until it is flush with the surface.
6. Squeeze the trigger until the caulking compound starts to come out the nozzle.
7. Keep squeezing the trigger until the joint is filled as you move to the bottom of the joint.

### Patching Cracks

1. Using a hammer and chisel, cut the crack to the desired size.

   NOTE: Wear your goggles.
2. Clean the crack of all loose material and moisten with water.
3. Fill the crack with mortar, making sure that the mortar is well compacted.
4. Smooth the top of the crack even with the adjoining surfaces.

# REMOVING FORMS AND FINISHING CONCRETE SURFACES

## OBJECTIVE

Upon completion of this workbook you will be able to remove, clean, and store concrete forms; and finish the concrete surface.

## EQUIPMENT

| | Basis of Issue |
|---|---|
| SG 3ABR55233-II-6 | 1/ student |
| WB 3ABR55233-II-6-P2 | 1/ student |
| Pencil | 1/ student |
| Paper | 1/ student |
| Mason handtools | 1/ student |
| Wheelbarrow | 1/ 6 student |
| Shovel | 1/ 6 student |
| Hoe | 1/ 6 student |
| Cement | 1/12 student |
| Sand | 1/12 student |
| Gravel | 1/12 student |

## PROCEDURES

### Mission 1

When you have completed this mission, you will be able to remove wall forms; use a carborundum stone to clean and finish a wall surface; fill surface voids; and clean, oil, and store forms.

### Removing Forms

1. Remove stakes and braces.
2. Cut tie wires.
3. Remove wales.
4. Move wall forms away from wall. Be careful not to damage wall surface.
5. Place forms away from immediate wall area.
6. Break tie wires from wall.

### Cleaning Wall Surfaces

As directed by the instructor, wet a specified wall area and remove excess concrete and stains with a carborundum stone.

Filling Voids

1. As directed by your instructor, prepare a cement and sand grout and fill voids.
2. As directed by your instructor, prepare a cement and sand slurry paste and fill voids.
   a. Apply the slurry paste with a brush.
   b. Rub the surface with a sponge float to insure filling of all holes.
   c. After the surface has dried, rub the surface with burlap to remove excess slurry paste.

Cleaning, Oiling, and Storing Forms

1. Clean form surfaces with a stiff wire brush.
2. Remove nails as required.
3. Apply a light coat of oil to the form face.
4. Stack the forms in their order of erection.

## Mission 2

The student will apply coverings to fresh concrete to obtain proper curing. The coverings will be applied as directed by the instructor.

Water

1. After concrete has hardened for a few hours, wet concrete surface thoroughly with water.
2. Check surface frequently to make sure that it stays wet.

Sand

1. Spread concrete surface with a layer of sand.
2. Wet sand with water.
3. Keep sand wet to ensure curing.

Fabric or Waterproof Paper

1. Place fabric over slab.
2. Wet fabric with water.
3. Keep fabric wet to ensure curing.

4. Moisten concrete with water.
5. Apply waterproof paper.
6. Overlap edges of paper to keep moisture under the paper.